AD-A091 422 SINGER CO BINGHAMTON NY LINK DIV F/G 19/3

DESIGN DEFINITION STUDY REPORT. FULL CREW INTERACTION SIMULATOR--ETC

JUN 78 N61339-77-C-0185

UNCLASSIFIED LR-895-VOL-1 NAVTRAEQUIPC-77-C-0185-000 NL

1 OF 2

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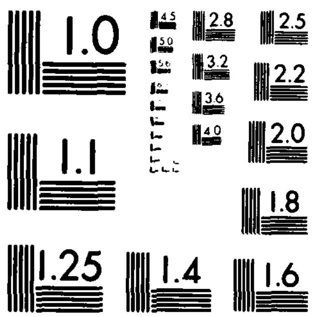

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Design Definition Study Report

Full Crew Interaction Simulator

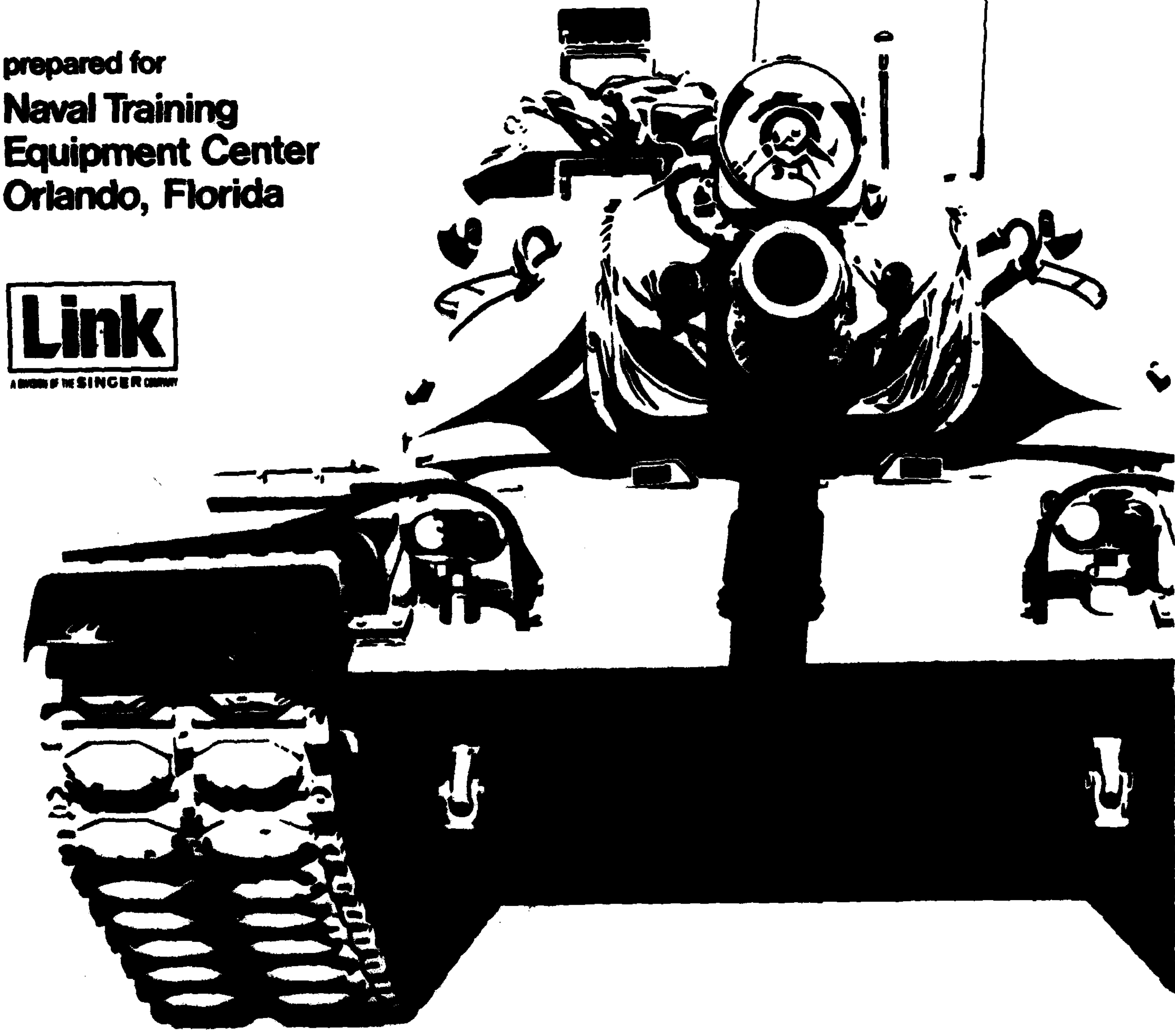
Laboratory Model (FCIS-LM) Device X17B7

prepared for

Naval Training Equipment Center
Orlando, Florida

Link

A DIVISION OF THE SINGER COMPANY



Report No: NAVTRAEQUIPCEN 77-C-0185-0001
LR-895

DESIGN DEFINITION STUDY REPORT

FULL CREW INTERACTION SIMULATOR-LABORATORY MODEL

(DEVICE X17B7)

VOLUME I - PROBLEM ANALYSIS

Link Division, The SINGER COMPANY
Binghamton, New York 13902

FINAL
June 1978

DOD Distribution Statement

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Prepared for:
NAVAL TRAINING EQUIPMENT CENTER
Orlando, Florida 32813

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4. TITLE (and Subtitle) DESIGN DEFINITION STUDY REPORT FULL CREW INTERACTION SIMULATOR-LAB. MODEL (DEVICE X17B7)		5. TYPE OF REPORT & PERIOD COVERED Final June 1978
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FOREWORD

This Design Definition Study is submitted by the Link Division of the SINGER COMPANY in accordance with the requirements of NTEC Contract N61339-77-C-0185, item 0001. It documents the study effort performed by Link in defining the requirements for, and the design approach to be followed in providing, a FULL CREW INTERACTION SIMULATOR-LABORATORY MODEL (FCIS-LM) for the M60A3 Battle Tank.

In the performance of this work, Link acknowledges the efforts of the Human Resources Research Organization (HumRRO), who, in the role of subcontractor, has provided valuable assistance in the analysis of tank operation and the determination of training requirements. The Link team is also grateful to the following US Government Agencies and DOD Contractors for their support and cooperation, without which this work could not have been completed in the time allocated.

- **Farrand Optical Co., Valhalla, N.Y.**
- **General Electric Co., Syracuse, N.Y.**
- **Systems Research Labs., Dayton, Ohio**
- **Chrysler Corporation, Warren, Michigan**
- **US Army M60 Program Office, Detroit, Michigan**
- **US Army Training Center (Armor), Ft. Knox, Ky.**
- **Naval Training Equipment Center (NTEC)**

SUMMARY STATEMENT

The FCIS-LM configuration resulting from the Link study effort is a two crew station configuration, a fighting station and driver station. Each station is mounted on a six degree of freedom motion system. The display medium for each visual system is a projector/dome configuration. The image generator is the Link DIG (Digital Image Generation). All optical instruments, including the tank commander's binoculars, are simulated with the DIG and small CRT's. The computational system is a multiprocessor Interdata 8/32 complex. Vehicle dynamics will be simulated using a kinematics approach. All vehicle systems will be simulated. Main gun simulation will use properly weighted ammo and will provide recoil and spent ammo ejection. The ballistics computer will be simulated in software. An instructor/experimenter station will provide display and control capability, visual system monitors and instructor driving controls.

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SECTION I

1. INTRODUCTION

1.1 Purpose

This Design Definition Study Report is the preliminary phase of a three-part task performed by the Link Division of the Singer Company to determine the technical feasibility and optimum design for a Full Crew Interactive Simulator-Laboratory Model (FCIS-LM) for the M60A3 main battle tank. The report documents the investigative and analytical efforts conducted to establish training objectives and requirements for the FCIS-LM device, and the development of critical simulation area design approaches to meet those training requirements.

Subsequent phases 2 and 3, the FCIS-LM Performance Specification and FCIS-LM Technical Proposal respectively, utilize the findings and design concepts provided in the study report to establish the final design and proposed approach to providing a complete FCIS-LM device.

1.2 Scope

The study necessitates the performance of three essential functions that are common to most problem solving tasks;

1. Define the problem, establish and assemble the relevant facts
2. Analyze and evaluate the facts to determine objectives, realistic goals, and requirements for a solution
3. Formulate conceptual approaches, and by means of 'Trade-Off-Analyses', select and develop a design for meeting the requirements with valid qualitative and quantitative criteria.

Figure 1-1 provides a structural breakdown of the report by section, subject, and volume.

Section I, besides explaining the scope and purpose of the report, presents a list of the data sources and reference material used throughout the report, a cross-reference matrix for the 5 contractual documents involved (i.e., the NTEC Study Outline, the NTEC Work Statement WS-2234-016, the Link FCIS-LM Performance Specification, the Link FCIS-LM Technical Proposal, this study report) and a statement of the tank training problem.

The following sections (2, 3, and 4), treat the vehicle, the crew, and the environment as a triad of forces where each influences each other, and analyzes the effects of these influ-

SECTION	SUBJECT	VOLUME	PURPOSE
1	INTRODUCTION		
2	VEHICLE PERFORMANCE ANALYSIS	I –	ESTABLISH AND ASSEMBLE THE RELEVANT FACTS
3	TACTICAL ENVIRONMENT ANALYSIS		
4	MISSION/CREW TASK ANALYSIS		
5	INTERACTIVE CREW TRAINING REQUIREMENTS		ANALYSE AND EVALUATE THE FACTS TO DETERMINE GOALS AND REQUIREMENTS
6	FCIS-LM EXPERIMENTAL REQUIREMENTS	II –	
7	FCIS-LM SIMULATION REQUIREMENTS		
8	VISUAL STUDY AND CONCEPT FORMULATION	– III	FORMULATE APPROACHES TRADE-OFF-ANALYSIS SELECT AND DEVELOP DESIGN TO MEET REQTS. WITH VALID CRITERIA
9	MOTION STUDY AND CONCEPT FORMULATION	– IV	
10	VEHICLE STUDY AND CONCEPT FORMULATION	– V	
11	TRAINING SYSTEMS STUDY AND CONCEPT FORMULATION	– VI	
12	STUDY CONCLUSIONS	– VII	

Figure 1-1 FCIS-LM Study Report Structure

ences. Section 2 presents an analysis of the vehicle's (M60A3 Tank) performance and systems, including controls, weapons systems, optical sighting devices, and communications equipment. Section 3 examines the tactical environment including terrain, climatic conditions, and threats and friendly forces. Section 4 considers tank mission profiles; the information available in the tactical environment that is utlized by the crew and the individual and interactive crew tasks performed during the mission. Figure 1-2 serves to indicate the relationships between the crew, the vehicle and the environment in terms of motion, visual and aural influences.

Section 5 identifies and establishes the need for specific training requirements based on the analysis described in the previous sections. This section reviews the current tank crew training programs presently employed at the U. S. Army Training Center (ARMOR) and provides information on individual and interactive crew task criticality and task performance conditions based on interviews with tank crew instructors and other experienced tank personnel.

Section 6 determines and specifies the need for FCIS experimental capabilities. It addresses the requirements for system flexibility (both hardware and software) and investigates the possibility of adaptive training features (varying task difficulty) and evaluates the merits of using very advanced highly flexible plasma type display and control panel hardware.

Section 7 specifies the simulation goals based on the previous investigations and analyses. This section does not recognize any constraints or limitations but defines simulation requirements regardless of cost, complexity or state-of-the-art so as to establish goals for meeting the training requirements.

Sections 8, 9, 10 and 11 describe the studies required for conceptual design approaches, trade-off analysis and ultimate selection and further development of the visual, motion, vehicle and training systems respectively. These sections include all of the technical arguments and rationales that form the basis for the selections, together with the achievable performance parameters and tolerance criteria.

Section 12 summarizes the results of all previous sections and further defines the critical simulation approaches to achieve correct cue correlation, particularly between the visual and motion disciplines. This section also serves to present the overall study conclusions and recommendations.

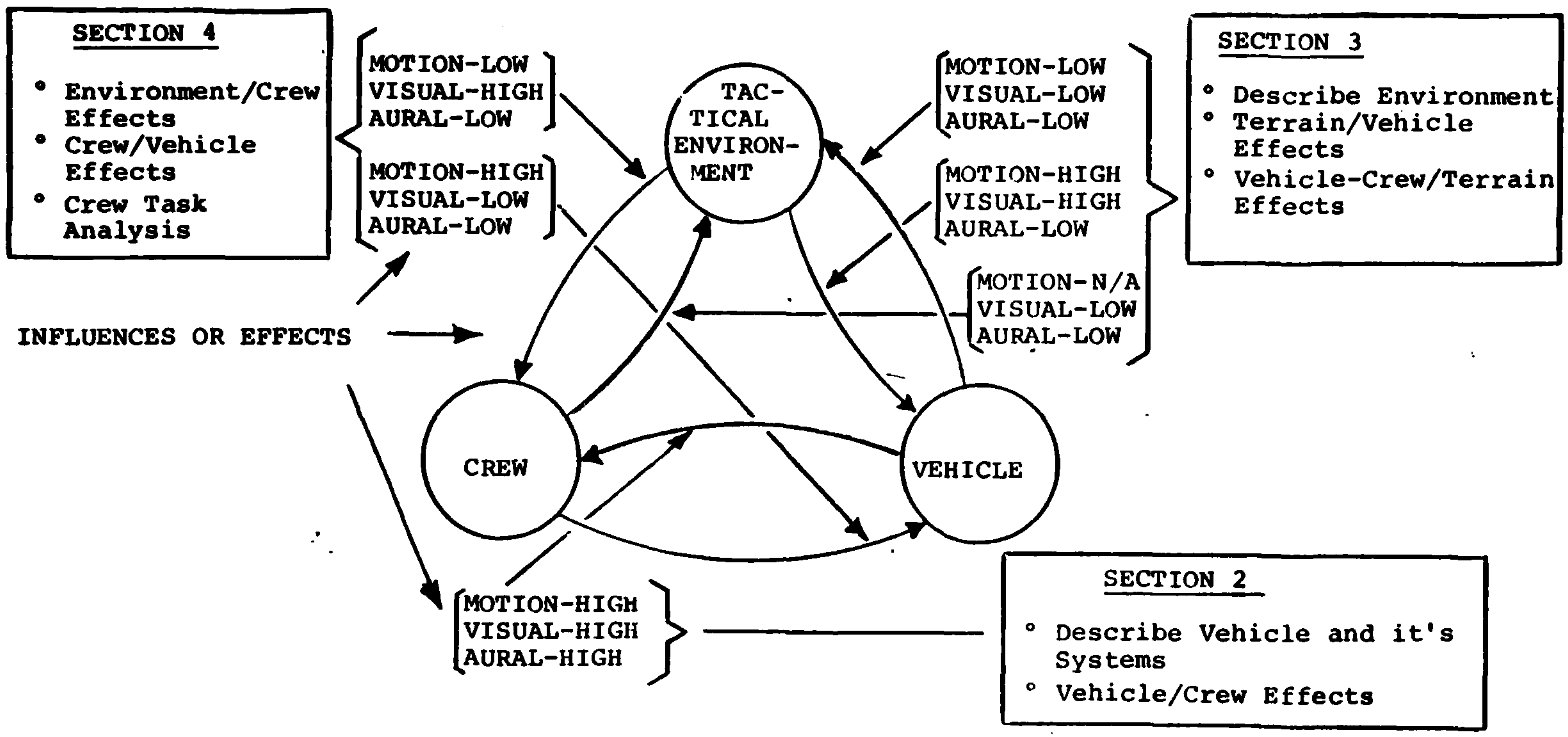


Figure 1-2 Crew/Vehicle/Environment Interactive Influences

TABLE 1-1 FCIS-LM DATA AND REFERENCE MATERIAL SOURCES

LEGEND

1 - U.S. Army Publications Center
2 - Link Division - Singer Company
3 - HUMMRO
4 - General Motors, AC Electronics Division
5 - Link-Miles
6 - Fort Hood, Texas
7 - NTEC
8 - Chrysler Corporation
9 - IDA
10 - Singer - Kearfott
11 - Hughes Aerospace
12 - U.S. Army Ballistics Laboratory, Aberdeen, MD

CODE	DOCUMENT NUMBER	TITLE
1	TM 9-1000-213-350	LIST, CANN/MT COMB/CUPOLA TANK/TANK CO
1	TM 9-1000-231-25	LIST, MACHINE GUN, CALIBER .50 M85
1	TM 9-10005-231-10	OPERATORS MANUAL, MACHINE GUN
1	TM 9-1220-220=34P	LIST, DRIVE BALLISTIC M10-10A1-10A3-10A4
1	TM 9-1240-262-34	TELESCOPE, ARTICULATED M105-105C-105D
1	TM 9-1240-262-34P	LIST, ARTICULATED TELESCOPE M105/M105D/M105F
1	TM 9-1240-313-34	PERISCOPE, TANK M32/M35Field Maintenance Manual
1	TM 9-1240-313-35P	PERISCOPE, TANK M32/M35, LIST
1	TM 9-1240-315-35	PERISCOPE, M37 FIELD DEPOT MAINTENANCE MANUAL
1	TM 9-1290-263-34	LIST, INDICATOR/AZIMUTH/INSTRUMENT/M28A1-28E2/37
1	TM 9-2520-223-34	LIST, TRANSMISSION, W/CONTAINER, MODEL CD850-5/-6A
1	TM 11-5820-401-12	LIST, RADIO SETS AN/VRC-12/43/45/46/47
1	TM 11-5820-498-12	LIST, RADIO SETS AN/VRC/53/64/125/160
1	TM 11-5855-249-10	OPERATOR/MANUAL/VIEWER/DRIVER/NIGHT/VISION
1	TM 11-5830-340-12	INTERCOMMUNICATION SET AN/VIC-1(V)
1	TM 11-5855-249-23P	LIST, VIEWER/DRIVER NIGHT VISION AN/VV2
1	TM 11-6625-613-45	LIST, SIMULATOR AIRCRAFT DISPLACEMENT AN/ASM
1	TM 9-6650-216-34	PERISCOPE, M24, FILED MAINTENANCE MANUAL
1	TM 9-6650-216-34P	PERSICOPE, M19 & M24, LIST
1	TC 71-5	REALTRAIN TACTICAL TRAINING FOR COMBINED ARMS ELEMENTS

TABLE 1-1 FCIS-LM DATA AND REFERENCE MATERIAL SOURCES (CONT)

CODE	DOCUMENT NUMBER	TITLE
1	TC 17-12-5	TANK, GUNNERY TRAINING
1	FM 17-11E1/1	SOLDIER, MAN/ARMOR/CREWMAN SK/LEV 1&2
1	FM 17-11E3	SOLDIER, MAN/ARMOR/CREWMAN SK/LEV 3
1	FM 17-12	TANK GUNNERY FIELD MANUAL
1	FM 17-36	DIVIS ARMOR & AIR CAVALRY UNITS
2	VOL. 1 PROPOSAL 1091	FCIS-LM DESIGN DEFINITION STUDY
2	VOL. 2 PROPOSAL 1091	FCIS-LM DESIGN DEFINITION STUDY
1	FT-105/50/7.62-A-2	FIRING TABLES
1	TM 11-2300-361-15-2	INSTL RADIO SETS AN/VRC-24
1	TM 9-1000-213-35	CANNON, 105MM GUN M68
1	TM 9-1005-233-10	MACHINE GUN, M73
1	TM 9-1005-233-24	MACHINE GUN, 7.62-MM M73
1	350-9 PAMPHLET	USERS MANUAL DVC 17-14 ARMOR COMBAT DECISIONS GAME (CDG)
1	M60A1-P1 M60A1E3	COMBAT TANK CHARACTERISTICS & DESCRIPTION BOOK
3	Charter 3 PGS145/20	THREAT ON MODERN BATTLEFIELD
1	ST 30-40-1 VOL. 1	SELECTED SOVIET WEAPONS & EQUIPMENT
1	14-4176	MILITARY OPERATOR SOVIET ARMY
1	TM 9-2350-257-34-2	TECHNICAL MANUAL, TANK COMBAT FULL TRACKED 105MM
	ADB015424L	EVAULATION, SMOKE AS DEFENSE AGAINST ANTITANK
1	ADA014728	AMC 74 MOBILITY MODEL-TACOM
1		STUDY, SHOCK/VIBRATION EFFECTS/VEHICLE TRAINER
1	TM 9-2350-257-20-2	TANK/COMBAT/FULL/TRACKED GUN RISE/TURRET
1	FM 17-12-2-UIFPR	GUNNERY TRAINER, TANK GUNNERY
1	TM 9-1240-315-35P	PERISCOPE, M37 DEPOT MAINT. MAN. REPAIR
1	AD471301	TANK MOBILITY ON SOFT SOILS
1	AD471302	TANK WEAPON STSTEM ANNUAL PROG. RPT 1965
1	AD604693	VIBRATIONS OF A MULTI-WHEELED VEHICLE
1	TM 9-2350-215-10	OP MAN, TANK, COMBAT, FULL TRACKED 105MM
1	TM 9-2350-257-10-2	TANK, COMBAT FULL TRACKED GUN TURRET
1	TM 9-2359-257-10-1	OP MAN, TANK, COMBAT FULL TRACKED, 105MM
4	SAE 670168	COMPUTERIZED EVALUATION OF DRIVER-VEHICLE-TERRAIN SYSTEMS
	AN/US6/2/TTS	TANK, THERMAL SIGHT INFRARED MAINT. COURSE

TABLE 1-1 FCIS-LM DATA AND REFERENCE MATERIAL SOURCES (CONT)

CODE	DOCUMENT NUMBER	TITLE
1	TM 9-2350-253-34P-1	MAINT., TANK, COMBAT HULL
1	LO9-2350-253-12	LUBRICATION ORDER, TANK COMBAT
3	CDE-SA-TR-71-09	MATH-REP OF M60A1 AZIMUTH & ELEV. CONTROL
1	TM 9-2350-253-20P-2	MAINT., TANK, COMBAT TURRET
1	TM 9-2350-253-34-2	DRAFT MAN. TANK COMBAT TURRET
3		FINAL INSPECTION RECORD, TANK, COMBAT F-TRA 70
1	TM 9-2815-200-35	MAINT., MAN., ENGINE/CONTAINER/FUEL INJECTION
8	DEP 9-2350-253-10	OP., MAN., TANK, COMBAT, F TRACK, 105MM M60A1
1	TM 9-6920-456-12	OPERATOR & ORGANIZATIONAL-MAINT. MANUAL
1	TM 9-1005-233-10	OPERATOR MAN. M73, M73A1, M219, MACHINE GUNS
10	CU01714079-1	PERFORMANCE SPEC. TEST PROCEDURE FOR OUTPUT UNIT
10	CU01714079-0	DWG M60 BALLISTICS COMPUTER OUTPUT UNIT
12	11732501	SCHEMATIC M60A1E3 GUNNERS CONT UNIT
11	74-36R HAC REF COL 52	XM21 BALLISTICS COMPUTER M60A1-P REPORT
12	MIL C 48596A (MU)	MIL SPEC. XM21 BALLISTIC COMPUTER SYSTEM
1	M60A1E3 TANK	LASER & BALLISTIC COMPUTER
6		ARMOR CREWMAN PERSONAL PROFILE
3	77-12	HUMMRO CRITICALITY & CLUSTER ANALYSIS
8		TRACKED VEHICLE RIDE DYNAMICS COMPUTER PROGRAM
1	DAHC 19-76-C-0001	TANK SYSTEM SKILL & TRAINING STRUCTURE
1	TM 9-2350-253-20-1	MAINT. MAN., TANK, FULL TRACKED-HULL
1	TM 9-2350-253-20P-1	TECH. MAN., TANK, COMBAT HULL
1	TM 9-2350-253-20-2	TECH. MAN., TANK, COMBAT TURRET
1	TM 9-2350-253-34-1	DRAFT MAN. TANK COMBAT HULL
1	TM 9-2350-253-34P-2	MAINT., TANK, COMBAT TURRET

1.3 Study Methodology

Over the past several years the Link Division of the Singer Company has undertaken numerous study and development contracts most all of which have been dedicated to the study of aircraft simulation and the training of aircrews, both for military and commercial purposes. The common objective in all of these programs has been the study of the simulation problems associated with complex equipment operating in the real-world environment, and each with the ultimate goal of achieving maximum training in the most cost-effective manner.

The simulation of complex equipment has ceased to be the major problem. Link has accrued a vast amount of experience in the simulation of all types of equipment including engines, engine related systems, transmissions, electronic equipment, radio communication and radar equipment together with a large selection of instruments and sophisticated display devices. Moreover, in these areas, a great deal of data is usually available to specify the detailed performance and operational characteristics, and furthermore the state of the art in digital computation technology permits a high degree of simulation fidelity to be realised.

This is not the case for simulation of the real-world and the environment in which the equipment operates, particularly in visual scene simulation where the state of the art has not yet progressed to the point where 100% realistic simulation can be achieved. Whilst a great deal of training can be obtained from the simulation technologies presently available, there still remains many problems to be solved in this area, especially with respect to dynamic realism or the presentation of subtle visual cues that are observed and translated by the human eye and brain into meaningful information.

The visual simulation problem is further complicated by the requirement for motion and the resultant need for exact correlation of the motion and visual cues. This is particularly true for the case of the FCIS-LM simulation requirements, since the visual scene with its associated tactical information, and sagacious vehicle movement together with precise target acquisition and gun laying are the most crucial factors to be considered in any tank combat training device. For this reason, the major portion of the FCIS-LM study effort has been devoted to the solving of the visual and motion problems. Figure 1-3 illustrates the methodology employed and indicates the most significant study steps and/or the factors involved in the design concept and development process.

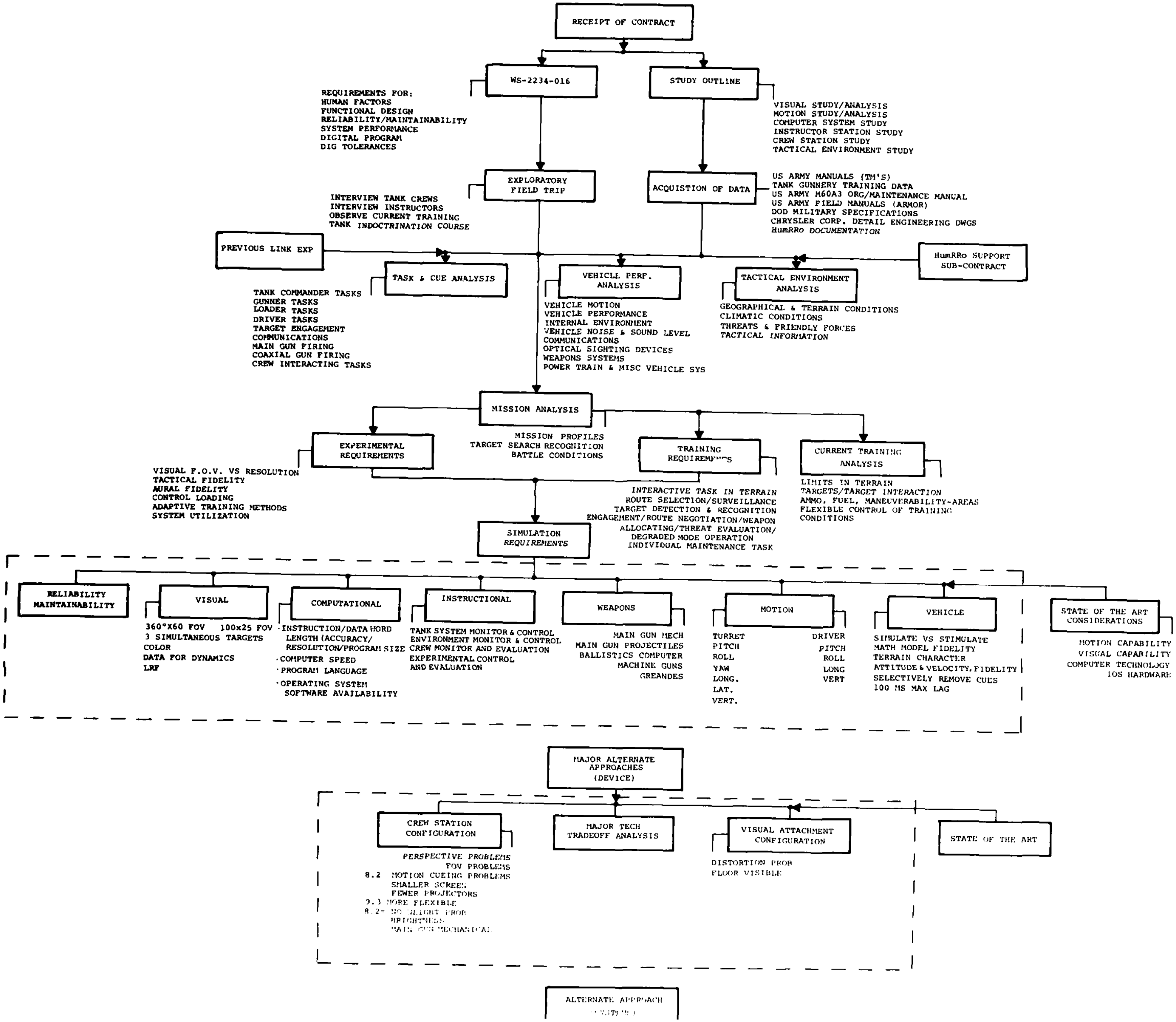
To help define the FCIS-LM problem, to identify specific crew training requirements, to assist in relating these training requirements to available simulation technology, and to provide in-depth support for the analytical study Link engaged the services

of the Human Resources Research Organization (HumRRO). This organization has a great deal of knowledge in armor training requirements by virtue of extensive study work in this and related areas.

Link study team personnel participated in the FCIS-LM Familiarization Conference, and also visited the U.S. Army Training Center (ARMOR) at Ft. Knox, partaking in a Tank Indoctrination course and where they were given opportunities to talk to seasoned tank crew members, and training instructors.

A data acquisition trip was also made to the Chrysler Corporation at Warren, Michigan for the purpose of obtaining vehicle specifications, drawings, reports and other forms of data. This information was supplemented by other data obtained from U.S. Army Technical and Field Training manuals.

A large portion of the study effort concerns the tradeoff analysis required to determine the most cost-effective design approaches, both in overall concepts and in specific systems. In those areas, the ultimate approach selections have been made on the basis of performance, complexity, system compatibility, reliability/maintainability and cost.



RECEIPT OF CONTRACT
WS-2234-016
STUDY OUTLINE
REQUIREMENTS FOR:
HUMAN FACTORS
FUNCTIONAL DESIGN
RELIABILITY/MAINTAINABILITY
SYSTEM PERFORMANCE
DIGITAL PROGRAM
DIG TOLERANCES
VISUAL STUDY/ANALYSIS
MOTION STUDY/ANALYSIS
COMPUTER SYSTEM STUDY
INSTRUCTOR STATION STUDY
CREW STATION STUDY
TACTICAL ENVIRONMENT STUDY
EXPLORATORY FIELD TRIP
ACQUISTION OF DATA
INTERVIEW TANK CREWS
INTERVIEW INSTRUCTORS
OBSERVE CURRENT TRAINING
TANK INDOCTRINATION COURSE
US ARMY MANUALS (TM'S)
TANK GUNNERY TRAINING DATA
US ARMY M60A3 ORG/MAINTENANCE MANUAL
US ARMY FIELD MANUALS (ARMOR)
DOD MILITARY SPECIFICATIONS
CHRYSLER CORP. DETAIL ENGINEERING DWGS
HumRRo DOCUMENTATION
PREVIOUS LINK EXP
HumRRo SUPPORT SUB-CONTRACT
TASK & CUE ANALYSIS
VEHICLE PERF. ANALYSIS
TACTICAL ENVIRONMENT ANALYSIS
TANK COMMANDER TASKS
GUNNER TASKS
LOADER TASKS
DRIVER TASKS
TARGET ENGAGEMENT
COMMUNICATIONS
MAIN GUN FIRING
COAXIAL GUN FIRING
CREW INTERACTING TASKS
VEHICLE MOTION
VEHICLE PERFORMANCE
INTERNAL ENVIRONMENT
VEHICLE NOISE & SOUND LEVEL
COMMUNICATIONS
OPTICAL SIGHTING DEVICES
WEAPONS SYSTEMS
POWER TRAIN & MISC VEHICLE SYS
GEOGRAPHICAL & TERRAIN CONDITIONS
CLIMATIC CONDITIONS
THREATS & FRIENDLY FORCES
TACTICAL INFORMATION
MISSION ANALYSIS
MISSION PROFILES
TARGET SEARCH RECOGNITION
BATTLE CONDITIONS
EXPERIMENTAL REQUIREMENTS
TRAINING REQUIREMENTS
CURRENT TRAINING ANALYSIS
VISUAL F.O.V. VS RESOLUTION
TACTICAL FIDELITY
AURAL FIDELITY
CONTROL LOADING
ADAPTIVE TRAINING METHODS
SYSTEM UTILIZATION
INTERACTIVE TASK IN TERRAIN
ROUTE SELECTION/SURVEILLANCE
TARGET DETECTION & RECOGNITION
ENGAGEMENT/ROUTE NEGOTIATION/WEAPON
ALLOCATING/THREAT EVALUATION/
DEGRADED MODE OPERATION
INDIVIDUAL MAINTENANCE TASK
LIMITS IN TERRAIN
TARGETS/TARGET INTERACTION
AMMO, FUEL, MANEUVERABILITY-AREAS
FLEXIBLE CONTROL OF TRAINING
CONDITIONS
SIMULATION REQUIREMENTS
RELIABILITY MAINTAINABILITY
VISUAL
COMPUTATIONAL
INSTRUCTIONAL
WEAPONS
MOTION
VEHICLE
STATE OF THE ART CONSIDERATIONS
360°X60 FOV 100x25 FOV
3 SIMULTANEOUS TARGETS
COLOR
DATA FOR DYNAMICS
LRF
·INSTRUCTION/DATA WORD LENGTH (ACCURACY/ RESOLUTION/PROGRAM SIZE
·COMPUTER SPEED
·PROGRAM LANGUAGE
·OPERATING SYSTEM SOFTWARE AVAILABILITY
TANK SYSTEM MONITOR & CONTROL
ENVIRONMENT MONITOR & CONTROL
CREW MONITOR AND EVALUATION
EXPERIMENTAL CONTROL AND EVALUATION
MAIN GUN MECH
MAIN GUN PROJECTILES
BALLISTICS COMPUTER
MACHINE GUNS
GREANDES
TURRET
PITCH
ROLL
YAW
LONG.
LAT.
VERT.
DRIVER
PITCH
ROLL
LONG
VERT
SIMULATE VS STIMULATE
MATH MODEL FIDELITY
TERRAIN CHARACTER
ATTITUDE & VELOCITY, FIDELITY
SELECTIVELY REMOVE CUES
100 MS MAX LAG
MOTION CAPABILITY
VISUAL CAPABILITY
COMPUTER TECHNOLOGY
IOS HARDWARE
MAJOR ALTERNATE APPROACHES (DEVICE)
CREW STATION CONFIGURATION
MAJOR TECH TRADEOFF ANALYSIS
VISUAL ATTACHMENT CONFIGURATION
STATE OF THE ART
PERSPECTIVE PROBLEMS
FOV PROBLEMS
8.2 MOTION CUEING PROBLEMS
SMALLER SCREEN
FEWER PROJECTORS
MORE FLEXIBLE
DISTORTION PROB
FLOOR VISIBLE
ALTERNATE APPROACH

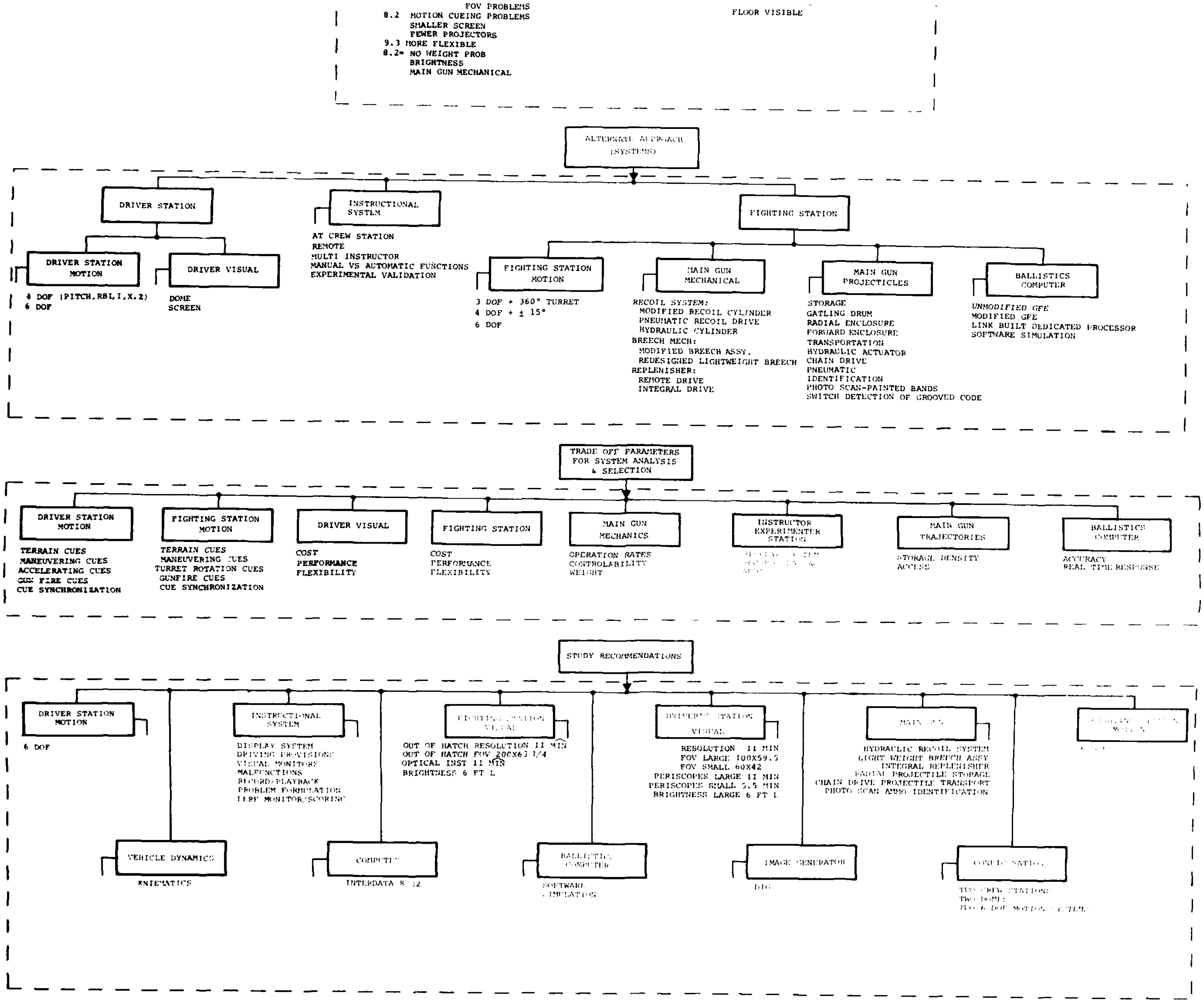


Figure 1-3. FCIS-LM Study Methodology

1.4 Data Sources

Table 1-1 lists the sources and types of data acquired by Link and utilized for the study effort. A complete list of the data items (in alphanumerical order) will be provided as an appendix to the final submission of this report.

1.5 Cross-Reference Matrix

A cross-reference matrix between the NTEC Study Outline and the NTEC Work Statement WS 2234-016 and the Link responses, i.e., the Study Report, the Performance Specification, and the Technical Proposal,is included in the Technical Proposal.

1.6 Statement of the Problem

Tank crews have traditionally, learned a major part of their most critical skills in combat. The complexity of tank crew tasks and of the tactical environment in which they are employed demand extensive training, but effective training necessarily involves crew interactions with the tank and the terrain, with threats and other friendly elements, which greatly exceed the resources available. Evaluation of the threats facing U.S. Armored units,make effective training absolutely essential. The initial losses of tanks, crews, and objectives in the early learning stages of armored warfare cannot be tolerated. Future engagements,if they take place,must be fought by crews who are thoroughly qualified to interact effectively with each other and with the pressures and stresses of tank combat.

Crew familiararity with the tank and its weapon systems can be developed in relatively simple and inexpensive settings, but tactical skills require practice in interacting with many complex situations which are impossible to provide in real-world settings. So far, these have not been represented by synthetic training systems, to the extent required for crew interaction training. Other military and civilian training programs have realized substantial savings in training costs through the use of simulation. In many of these programs normal proficiency levels have been exceeded through increased training efficiency, and through training which would be too expensive or too hazardous to accomplish in real world settings. Simulation promises to permit similar savings and training efficiencies for M60A3 crews, but the complexity of the crew training requirement seems to exceed the capabilities of the simulation approaches so far developed for other training programs.

The tank crew's interaction with the tactical environment relies heavily on dynamic visual information about the terrain, the threat and the effects of friendly and hostile weapons. The crew also operates in a complex motion environment which provides task information, and which also makes effective performance of most skills more difficult. In addition, the tank crew operates as a precisely articulated team. Each individual task is precisely tailored to the tactical situation and to the performance of each other member of the crew. The driver's selection of a route, and the way he negotiates it influences the ability of the commander and the gunner to acquire and engage threats. The ability of the loader to keep the tank's guns operating influences its ability to survive on the battlefield, while the accuracy of the commander and the gunner in threat detection and engagement influences the survival of the tank and the effectiveness of its mission. The degree of integration required of the M60A3 crew requires practice and quidance in carefully-controlled settings, not available in real-world training exercises.

While simulation appears to have promise for the representation of the M60A3 and its environment, and for the systematic control of crew training, the technology must be adapted to the crew's specific needs. One of the purposes of this study has been to identify those needs in terms of critical training objectives, relevant to the employment of the M60A3 tank in a combat environment. Another purpose has been to define simulation and training concepts capable of supporting these objectives, while a third function was to identify research issues to be explored in the refinement of simulation and training system characteristics for maximum support of tank crew training.

The problem for the study has been to identify M60A3 crew interaction training objectives, to define simulation concepts nominally capable of supporting them, and to develop system design concepts capable of supporting crucial experiments in the design of specific crew interaction training features. Much of the attention of the study has been devoted to the identification and description of the information used by the crew in performing its tasks, and essential to tank learning. Much of the effort has been oriented toward visual information and visual cueing, because of the inherent complexity of the visual environment of each individual crewmember, and of the crew as a coordinated team.

The information value and the distractions and stresses associated with tank motion have also been studied in detail. In many cases, the motion of the tank is the most useful cue available to the crew about the performance of the driver. In many situations also the motion of the tank determines the way in which the rest of the crew must perform; many critical skills must be performed differently when the tank is in motion than when it is stationary.

Lack of experience in the systematic development of crew interaction skills necessitated attention to the instructional technology to be employed in the full crew interaction simulator. Individual skills, in the M60A3, are rarely practiced in isolation from the rest of the crew. Each function of the tactically employed tank involves responsibilities on the part of each individual. Learning to execute these responsibilities in the crew tactical situation involves training problems which seem to be almost totally unique to the tank environment, requiring in turn, unique approaches to instruction.

Finally, a major problem in the study has been to identify and define capabilities required of the simulator, and training system design resources. The technology available for tank crew interaction training, especially in the simulation of visual cues and in the optimal control training has never been demonstrated in any training problem similar to that faced by tank crews. Extrapolations of the available technology to tank crew training will be to some extent inaccurate, ineffective and costly, until experimentation has been able to establish adequate, economical approaches. Much of the current technology was developed in the aviation context but the tank crew's demands on the technology, especially in the representation of the visual environment, exceed those so far placed on it by the aviation community. In addition of course, the level, precision, and timing of crew interactions and the stresses on the crew are almost unequalled in any other weapon system. Extensive research is required in tank crew training to make the FCIS concept capable of maximum support to Armor.

SECTION II

2. VEHICLE PERFORMANCE ANALYSIS

This section examines the M60A3 Combat Tank's performance and analyzes the relationship between the tank as a vehicle (including its equipment and weapons system) and, (a) the tank crew, and (b) the tactical environment in which the tank and crew operate.

Much of the information for this examination and analysis was obtained by Link Study Team personnel during a field trip to the U.S. Army Training Center (ARMOR), Ft. Knox, Kentucky. At Ft. Knox, study personnel participated in a short, but extensive tank indoctrination course, during which they were permitted to interview experienced tank crewmen and training instructors. In persuance of the study program, additional data were obtained from manufacturer's specifications, reports, and drawings, and U.S. Army technical manuals.

It is the intent of this section not to define or specify M60A3 tank performance characteristics (this information is well documented elsewhere), but to identify its most salient features and operational characteristics from a simulation viewpoint. These features are used to establish meaningful criteria for vehicle and turret motion, aural cues, armament and ancilliary systems, optical sensing devices, and crew station configuration.

2.1 Vehicle Motion Analysis

The M60A3 Combat Tank is a heavily armored track-laying vehicle manned by a crew of 4. In operation, the tank traverses the terrain at varying speeds with the tank attitude at all times being dictated by the terrain geometry and the vehicle's center of gravity and related footprint. In movement, the vehicle is subjected to kinematic forces in all 6 degrees of freedom of movement. At relatively high speeds (in excess of ten mph (16 kph.) and over rough or severely undulating terrain, these forces become appreciable with pitch, roll and heave being the most dominant. Longitudinal, lateral and yawing moments are also present, but less noticeable to the crew. Acceleration and deceleration effects due to starting and stopping the tank are apparent along the longitudinal axis. Movement and related dynamic effects of the vehicle suspension system, combined with reactionary forces due to the tank engine and transmission, also cause considerable vibration of the vehicle structure. Kinesthetic effects of vehicle motion and vibration on the crew have an important bearing on their ability to perform the physical tasks required in tactical operations. Because of locations of the crewmembers in the tank, vehicle motion has different effects on each of them. Figure 2-1 illustrates the relative locations of the individual crewmembers with respect to the tank and its major components.

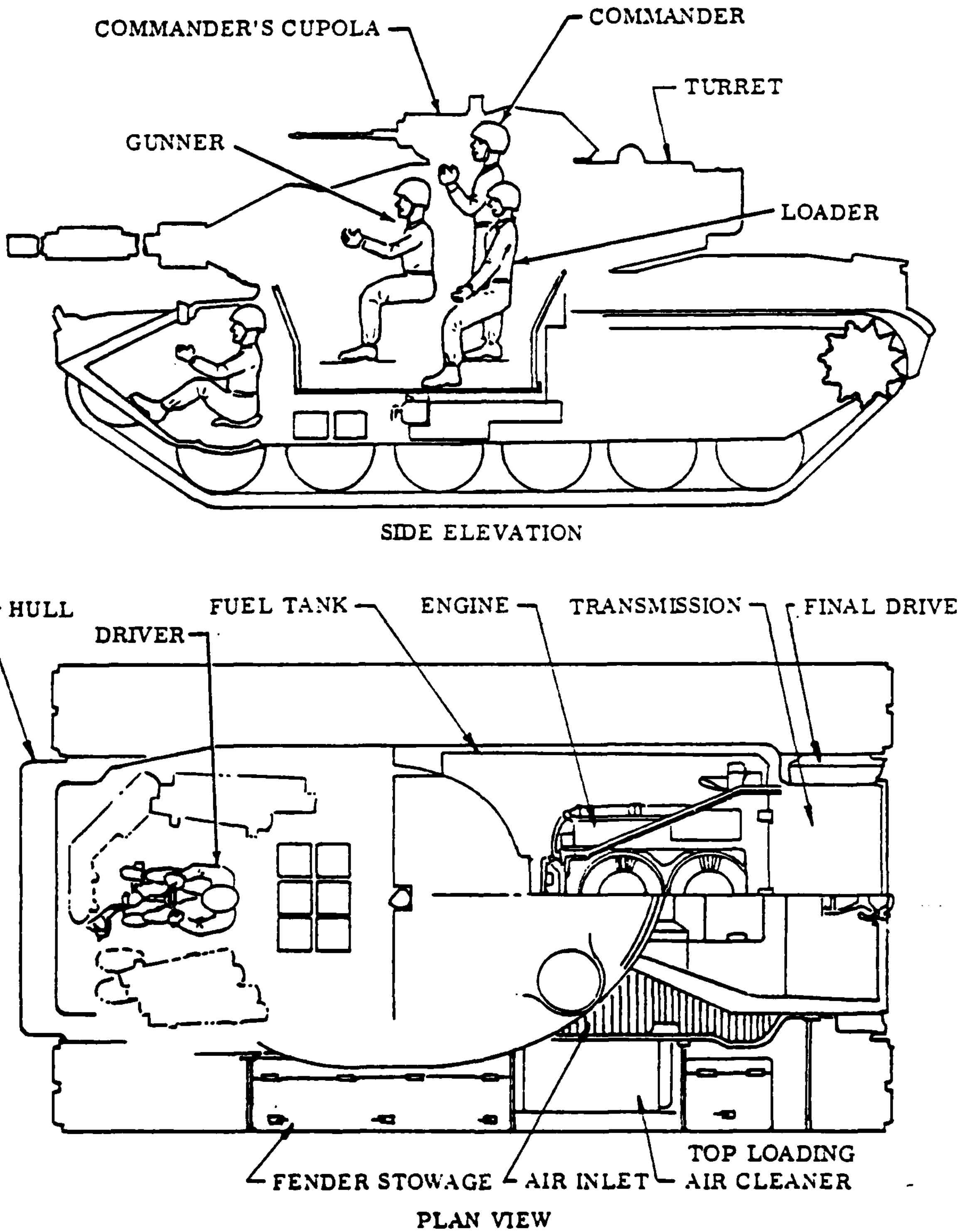


Figure 2-1 M60A3 Tank (General Arrangement)

The following subsection identifies major vehicle performance parameters and characteristics that were analyzed and evaluated to determine motion simulation requirements and to define vehicle dynamics presented in Sections 7 and 9 of this report.

2.1.1 Vehicle Performance Characteristics. The M60A3 is powered by an air-cooled, 750 horsepower diesel engine with power transmitted to the final drive through a cross-drive transmission. The cross-drive transmission includes differential, steering, and braking functions. The following are the vehicle characteristics effecting motion performance:

a) Total vehicle weight (less crew, storage and fuel	104,186 pounds
b) Total vehicle weight, combat loaded	113,730 pounds
c) Nominal center of gravity	
o X longitudinal (from bow to hull)	128.0 inches
o Y lateral (positive, right of centerline)	0.6 inches
o Z vertical (from ground line)	54.4 inches
d) Forward maximum speed	
o High	30 mph
o Low	10 mph
e) Reverse maximum speed	7 mph
f) Maximum gradeability (i.e., implies maximum pitch)	60 %
g) Maximum side-slope (i.e., implies maximum roll)	30 %
h) Maximum trench	102 inches
i) Maximum fording depth (without kit)	48 inches
j) Cruising range (paved, level roads)	300 miles at 20 mph
k) Acceleration (hard road)	
o 10 to 30 mph	100 feet
o 10 to 20 mph	43 feet
o 0 to 10 mph	11 feet
m) Maximum tractive effort	77,000 lb at 1960 rpm
n) Towing effort (drawbar pull)	8,300 lb at 12 mph

The track data (T142) relevant to the mobility of the vehicle are:

a) Width	28 inches
b) Length	166.72 inches
c) Height (above steel grouser)	0.89 inches

Therefore, the ground pressure for the M60A3, combat loaded tank with the T142 track is 12.1 psi. The track is driven by the rear drive sprockets and support hulls attached to the final drive assemblies.

The M60A3 combat tank is equipped with a torsion bar suspension system connected to six individually suspended roadwheels per

side. Compensating idler wheels and track adjusting linkages are installed at the front of the tank and connected to the front roadwheel. Correct track tension is provided via the track adjusting linkage. The twisting action of the torsion bars aids in maintaining maximum ground/track contact.

Tracked vehicle mobility can be described as the ability of the soil to support the vehicle statically or in motion, as well as to provide thrust. Mobility can be assessed only by a combination of relevant physicogeometrical values pertaining to both the soil and the vehicle. Relevent vehicle data is generally the load-form size relationship of a given design as described in this section. Appropriate terrain characteristics are described in Section 3.1.2 "Vehicle Mobility Considerations".

2.2 Internal Environment Analysis

This section examines the internal working environment of the vehicle,and how this environment influences the crew from the standpoint of;

- o Condition of air and ambient temperatures
- o Vehicle noise and sound levels
- o Vehicle Vibration
- o Crew Communications

2.2.1 Crew Station Air Conditions. Whenever a number of people have to work in closely confined quarters (particularly under arduous and high stress conditions), the quality of the breathing air takes on a significant importance. In the M60A3 vehicle, the quality of the air, specifically purity (presence of toxic funes and/or homogeneous compounds) and temperature, are likely to approach undesirable levels. This is especially true in closed-hatch combat situations when vehicle engine systems are taxed for maximum performance and the main gun is being fired. Also, in extreme climates (subfreezing or tropical circumstances), the temperature of the air and surrounding contact surfaces of the vehicle, particularly the driver's compartment, will not be conducive to the high-efficiency required for the performance of M60A3 mission tasks. Study and evaluations at Ft. Knox were conducted in an "open hatch" configuration. Therefore, "closed hatch" combat conditions were not experienced. The outside air temperature was in the 50°F to 55°F range and moreover the operational tempo was considerably slower than that encountered under actual combat conditions. However the conditions alluded to are very real and play an important role in the operation of the vehicle and it's systems and therefore must be considered in any training concept to develop individual and interactive crew skills.

To minimize effects of temperature and air conditions on crew performance, the M60A3 Vehicle is equipped with the following systems:

- o Personnel Heater
- o Ventilation System
- o Gas Particulate System

These equipments and systems and their operation are described in Section 2.6.6.

2.2.2 Vehicle Noise and Sound Levels. Tank sound characteristics can be categorized by four areas of tank operation. These are: engine starting and running, mobility or driving, weapon system operations, and miscellaneous internal turret and hull equipment operation.

Engine starting and running sounds are typical of a diesel engine. Since the engine is air cooled, sounds produced by rapid moving air are also a characteristic. Intake and air-cleaning fans and the turbosupercharger create additional moving air sounds as well as a whining sound similar to a jet engine. Electrical fuel pumps located within the fuel tanks, also create quiet but noticeable hum.

Mobility sounds consist of track squeak, a transmission and final drive moan typical of heavy equipment, and an automatic transmission whine typical of hydramatic transmissions. Also, intermittant hull and turret vibrations due to vehicle motion create internal rattles and clatters in base equipment, plumbing, and sheet metal.

Weapon system operation, related to firing the tank guns, provides explosive as well as mechanical sounds. The main gun explosion also creates a blast effect typical of its size and caliber. The hydraulic mechanical ejection mechanism of the main gun and the ejected shell casing also produce sounds, typical of this type of operation. Firing of the coaxial (7.62MM) and the 0.50-caliber tank commander's machine gun cause sharp staccato reports. Automatic operation of ejection mechanisms also generate characteristic sounds. Cartridge casing ejection and cartridge belt feed also produce sounds associated with automatic machine gun operation.

Miscellaneous internal turret and hull equipment sounds are obvious when the engine is off and weapons are not firing. These sounds are generated by the ballistic and super elevation drive unit (motor driven gear train), the electrically driven hydraulic pump, the turret drive unit, the main gun elevation actuator, and the stabilization system gyros. Also included in the unique equipment sounds are those of the bilge pump, exhaust fan, and personnel heater. The clatter of heavy duty relays

and solenoids, as well as the clicks of switches generate sounds of electrically controlled equipment. Squeaks, thumps, and knocks are the sounds typical of mechanically controlled equipment.

Sounds generated by turret equipment tend to echo and reverberate due to the confined space, type of material used in construction, and lack of sound-deadening material. Opening or closing hatches does not noticeably reduce the echo effect. Also, the echo effect decreases the capability of determining the direction of a sound. Externally generated sounds entering through the hatch also create an echo within the turret.

Internally, sounds emanating from the hydraulic pump, turret drive and blower prevent the crew from carrying on conversations. Regardless of whether hatches are opened or closed it is difficult to conduct a conversation, even at shouting levels. Sound levels from internal and external sources reach levels that can be dangerous to human ears. It is estimated that ambient sound levels reach an amplitude of 110 db. This noise level is substantially reduced (approximately 25%) when protective helmets are worn. The crew's helmets also provide built-in communications equipment as well as physical protection.

Closed hatch operation does not appreciably reduce the noise level of externally produced sounds as there are openings between the hull and turret, through the blower assembly, in the fire wall, and around the gun mount. The cupola also has many openings that allow external noises to penetrate to the hull's interior.

2.2.3 Vehicle Vibrations. The tank crew senses vibrations due to both the engine operation and the vehicle/terrain motion. Terrain motion induces relatively low frequency (less than 1.0 HZ) vibrations on the vehicle while the engine contributes higher frequencies (5-15HZ). However, the terrain causes the crew to be subjected to higher accelerations than the engines. Vibration is sensed at all crew stations, but the engine vibrations tend to be of larger magnitude at the turret than at the driver's station.

2.2.4 Communications. The tank communication system is the medium for effective crew interaction and as such is an important element in rapid target engagement. The M60A3 is equipped with an intercommunications set AN/VIC-1 (V) which facilitates crew intercommunications and allows individual crewmen to use the tank's radio set. An external unit permits personnel outside the tank to communicate with the tank crew members and to use the tank's radio set. This external unit may also be utilized to connect the inter-communications set to an existing telephone line.

The M60A3 may also be equipped with any of the following radio sets; AN/VRC-12, -46, -47, -53 or -64. These radio sets provide short range (5 to 20 miles), two-way, frequency modulated (FM) radio communication in the frequency range of 30.00 to 75.95 megahertz (Mhz).

A typical M60A3 communication system configuration in which an AN/VRC-12 radio set is integrated with the AN/VIC-1(V) intercom system is presented in Figure 2-2 . Power is provided by the tank's battery system. An electrical transient suppressor protects the communication system from transient voltages in the vehicular electrical system. This unit also contains a circuit breaker to interrupt power in case of an overload. It may be noted that the tank's generator, electric fuel pumps, powerpack electric motor, ventilating blower motor, air cleaner blower motors, and personnel heater motor are designed to minimize radio interference by the use of shielding, feed-through capacitors, plated tooth-type lockwashers, and braided bond straps. Control and frequency selectors, shown in Figure 2-2, provide remote selection of any of the 10 preset frequencies of the RT-246/VRC. The preset frequencies may be changed at the receiver-transmitter. Control boxes are employed to provide crewmember audio control and to interface with intercom accessories (CVC helmet, etc.).

Radio sets AN/VRC-12, -46 and -47 have dual-band frequency ranges (Band A, 30.00 to 52.95 Mhz; Band B, 53.00 to 75.95 Mhz). The high power range of these units is 20 miles stationary, 15 miles moving, and 1 mile submerged. Output RF power is 1 to 3 watts in low power and 35 watts minimum in high power. AN/VRC-12 has 10 preset frequencies while AN/VRC-46 and -47 have none. The AN/VRC-53 and -64 radio sets are single-band (30.00 to 75.95 Mhz), low power units (1 to 3 watts) with a five mile range. The AN/VRC-53 and -66 have 2 preset frequencies. All units have 920 channels, each separated by 0.05 Mhz. Each has a squelch tone signal of 150 Hz.

2.3 Optical Sighting Devices

2.3.1 Driver Compartment. The M60A3 tank driver has two optical sighting devices available - a set of 3 M27 periscopes and an AN/VVS-2 Night Vision Viewer.

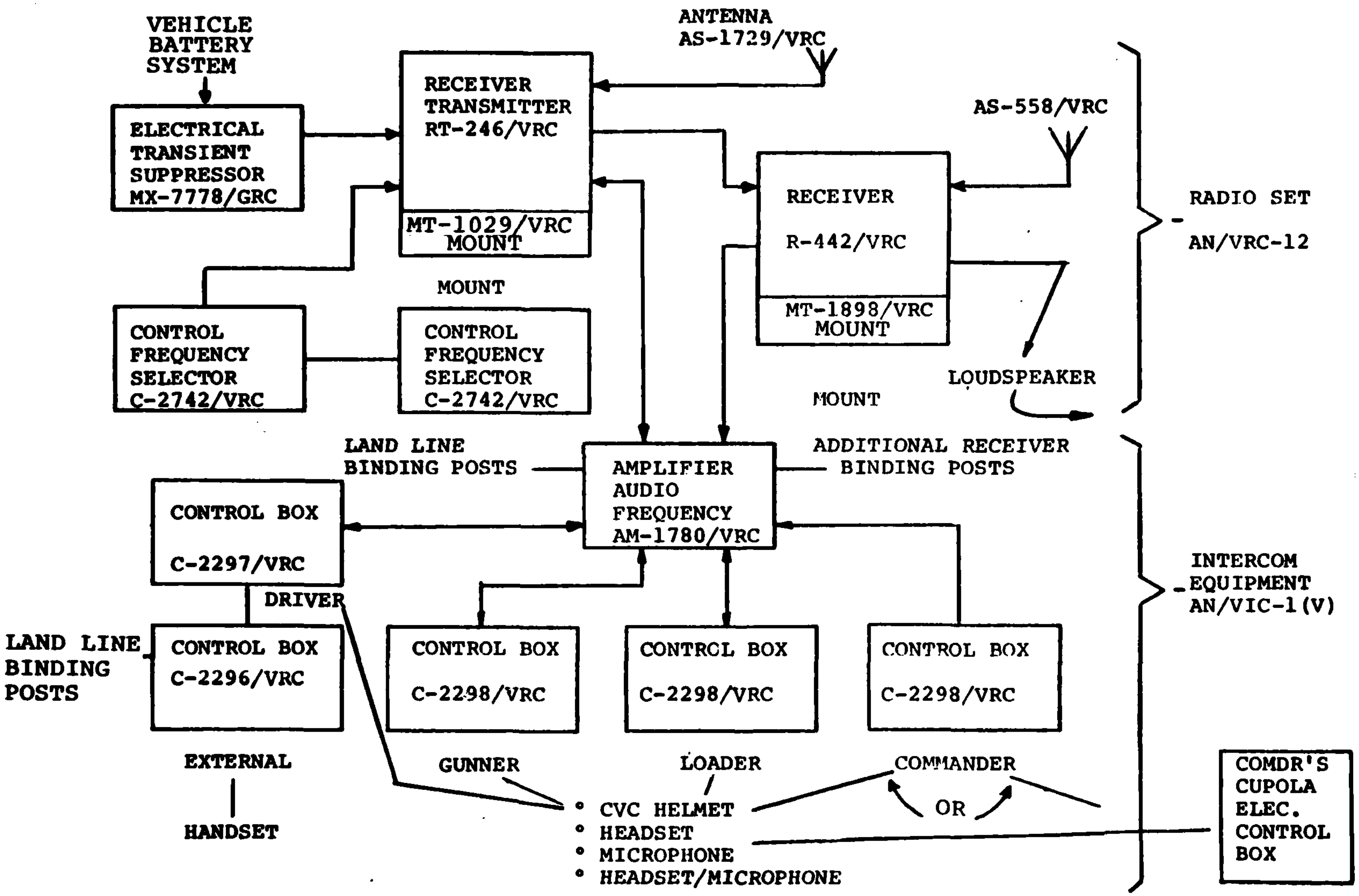


Figure 2-2 Typical M60A3 Communications System Configuration

The three M27 periscopes act as vision blocks for the driver to allow him to see out of the tank when the hatch is closed. The periscopes are located in front of and to the left and right of the driver and are separated by an angle of 144° from his eyepoint. (See figure 2-3A)

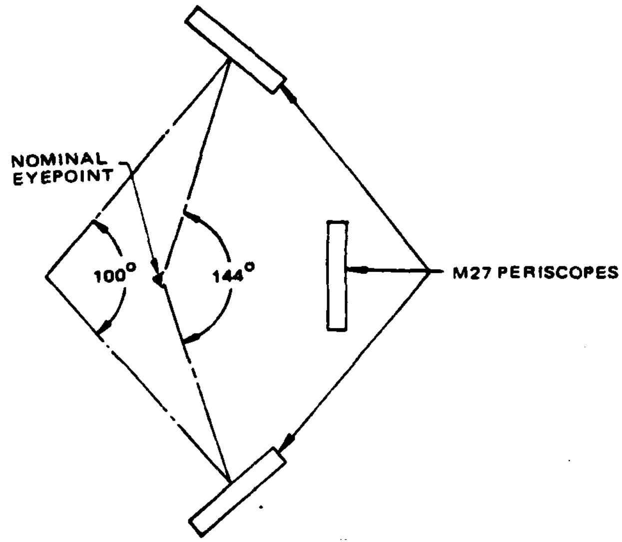


Figure 2-3A Driver's Vision Blocks

Each M27 periscope permits viewing a rather wide FOV if the driver moves his head to enable him to see the extreme of the FOV. Measurements taken on the tank indicate that the maximum FOV for any one periscope is 120° horizontal by 32° vertical. Thus there is considerable overlap between adjacent windows. (See figures 2-3B and 2-3C)

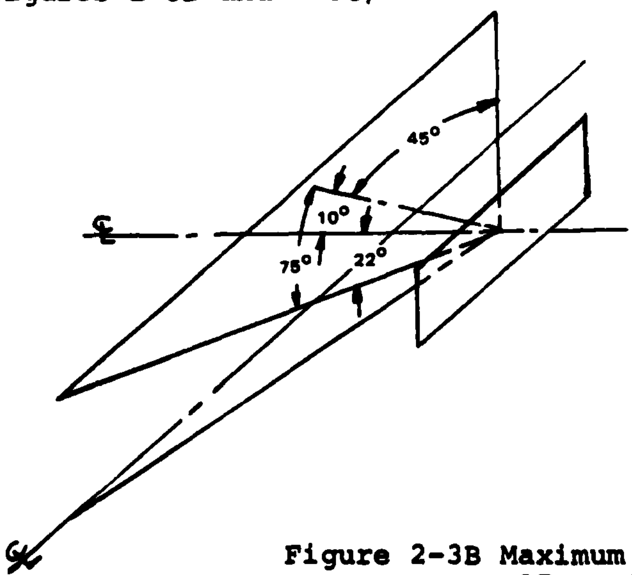


Figure 2-3B Maximum Field of View for M27 Periscopes

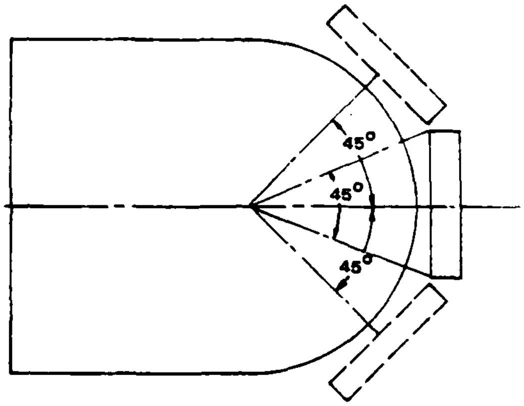


Figure 2-3C Nominal and Extreme Positions of the AN/VVS-2 Night Vision Viewing Device

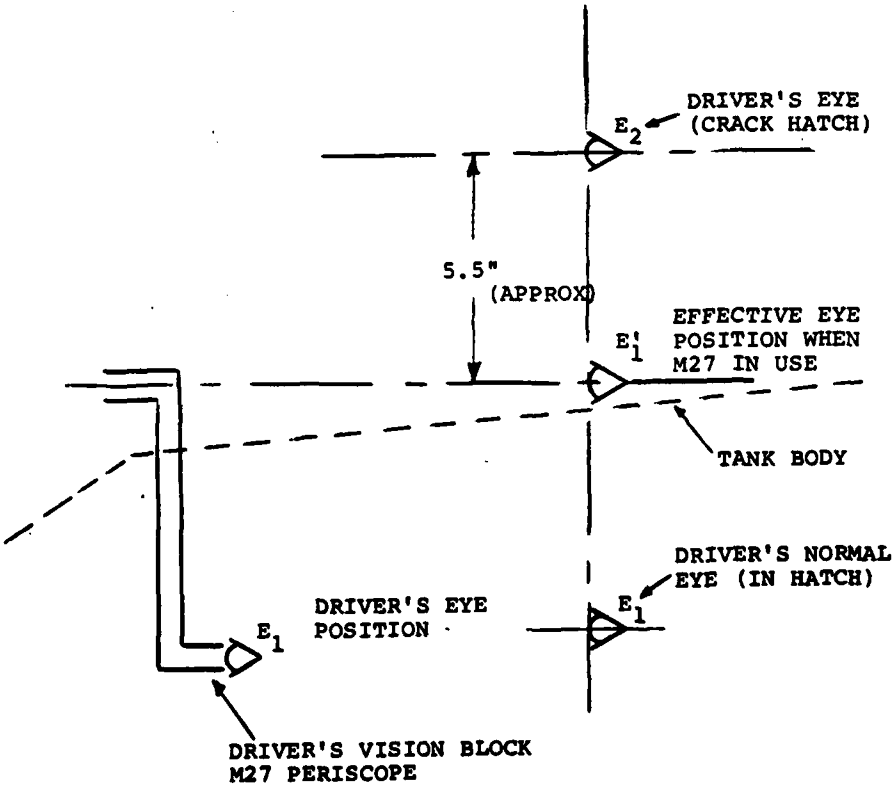


Figure 2-3D Driver Eyepoint Positions

More commonly, only about 80% of the FOV is used.

Note that whenever an M27 periscope is used, the effective eye point is very nearly equal to the eye position of the driver when he is driving with his head out of the hatch. See Figure 2-3D.

The AN/VVS-2 Driver's Night vision viewer is a 1-power, totally passive viewing device which allows the driver to see at night or in conditions of poor visibility. The device, installed in the driver's hatch, permits vision through one large eyepiece and does not require facila contact against the bump padding.

The AN/VVS-2 has a field of view of 45° horizontally and 38° vertically. In addition it can be horizontally rotated $\pm 45^{\circ}$.

2.3.2 Loader Station. The primary viewing device for the loader is an M37 Periscope. This instrument is a unity-power viewing device used for surveillance when the vehicle is "buttoned up". The M37 is manually capable of full 360° rotation. The instantaneous field of view is 72° horizontal by 26° vertical.

2.3.3 Gunner Station. The gunner has two sighting devices available for use. These are the M35E1 periscope and the M105 Articulating Telescope.

The M35E1 periscope is the gunner's primary sighting device. The periscope has a unity-power and 8-power daylight viewing system and an 7.1 power passive night capability. The unity viewer provides a panoramic observation view and is equipped with an aiming circle for use with the coaxial machinegun. The 8-power systems are used during sighting and main gun laying in either daylight or limited visibility conditions. The passive system requires no other lighting system such as a searchlight or a high voltage IR power system to operate.

In addition, the reticles produced in the 8X sight are projected by the XM21 Reticle Projector and reflect adjustments made by the ballistics computer to account for range deflection, wind speeds, etc.

The unity power system has a field of view of 30 degrees 32' horizontally by 5 degrees 48' vertically and is aligned coaxially with the main gun. Field of view for the 8X visual and the 7.1X thermal devices is 8 degrees and 7.3 degrees respectively.

Both of the powered sights require that the gunner place his eye to an eye rest in order to view the image.

The gunner's backup sighting device is the M105 Articulating Telescope. This device, also mounted coaxially with the main gun, contains a dual ballistic reticle with patterns for three

types of ammunition. The telescope has 8-power magnification and a field of view of 7 degrees 30'. It is capable of 10 degrees of depression and 20 degrees of elevation.

2.3.4 Tank Commander Station. The tank commander's optical devices include the M36El periscope, AN/VVG-2 Laser Range Finder, and binoculars.

The M36El periscope is used by the commander (in the cupola) for surveillance and sighting of the 0.50 caliber machine gun. This perisocpe is similar to the gunner's M35 in that it has a unity, an 8-power daylight, and an 8-power passive night capability. The systems differ in the field of view presented to the commander and the type of reticles. In the M36, the periscope is mechanically linked to the machine gun and presents a 60° X 28° field of view in the unity system, a 10° field of view for the 8X visible, and a 7.3° field of view for the thermal eyepiece.

Unlike the gunner's periscope, reticles on the 8X eyepiece are not controlled by the XM21 reticle projector.

The periscope is capable of 60° of travel in elevation and 20° of travel in depression.

The laser rangefinder (AN/VVG-2) is used by the commander to determine ranges of various objects. Range is determined by transmitting laser light pulse at a target and converting the time from transmission to reception into range. The rangefinder can store data on as many as three targets in the path of the laser.

The laser rangefinder optical system is equipped with a low magnification viewing mode for acquiring targets and a high magnification viewing mode for ranging and gun laying. In addition, the optical system of the laser rangefinder serves as the commander's primary sight for directing fire of the main gun. The optical system provides a means of introducing azimuth corrections into the pointing of the laser rangefinder to compensate for target lead. The laser rangefinder's optical system provides means whereby boresight of the laser rangefinder, with respect to the main weapon, can be checked and adjusted.

A detailed description of the Laser Rangefinder is located in Section 2.4.2.1.

The following data characterizes the AN/VVG-2 rangefinder:

Model	AN/VVG-2
Operating Range	200 to 5,000 meters
Range Resolution	Capable of resolving two targets a minimum of 20 meters apart.
Range Accuracy	± 10 meters

Ranging

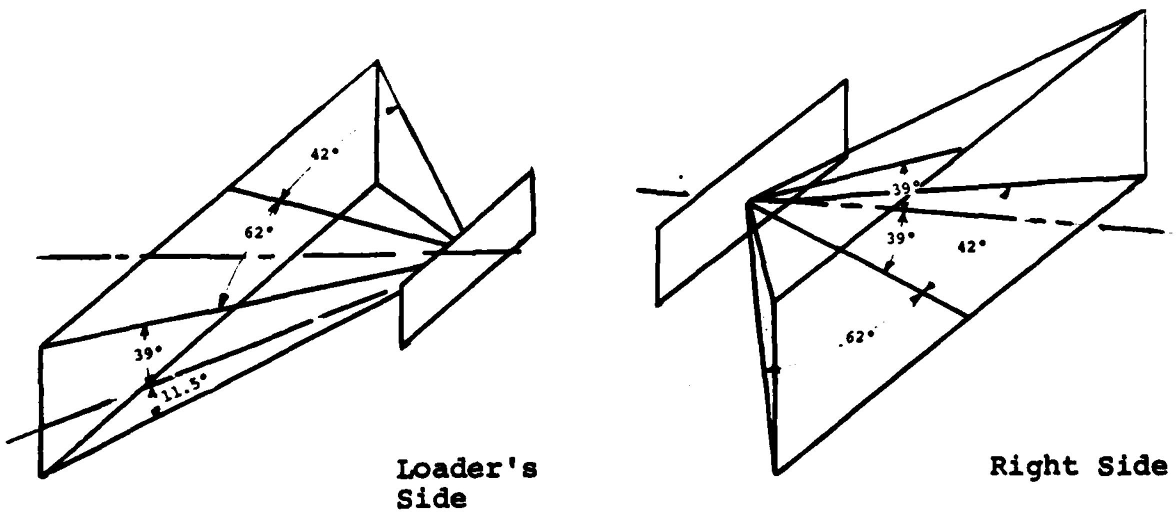
Maximum recycle time	4 seconds
Minimum sustained ranging W/O Overheating	3 per minute sustained or 6 per minute for 2 minutes with 3-minute intervals between each 2-minute ranging period

Telescope	Low Power	High Power
Magnification	6 power ±5%	12 power ±5%
Field of view	10 degrees ±5%	5 degrees ±5%
Exit pupil diameter	7.0mm ±5%	4.2mm ±5%
Eye relief	1.1-inch minimum	

Reticle — Ballistic reticle

Another optical instrument available for use by the tank commander is his binoculars. The binoculars are used in detecting distant objects, searching for information about an area's ability to conceal threats, and searching for good tactical routes. Normal binoculars give about 7x magnification over a 7.5° field of view.

The commander also has eight unity-powered vision blocks in the cupola to allow him to view 360° when all hatches are closed. The vision blocks are 2½-inches high by 8½-inches wide. The fields of view of adjacent blocks overlap. All of the vision blocks have slightly different fields of view due to tank superstructure. Figure 2-4 shows two typical (extreme) cases.



(Typical)

Figure 2-4 Commander's Vision Blocks

2.4 Weapons System

The M60A3 weapons system is comprised of 3 major component groups:

- The 105mm (main) gun, a.50 caliber machine gun, a 7.62mm coaxial machine gun, and the associated ammunition for each weapon.

- Sighting and Fire Control System.

- Stabilization System.

2.4.1 Guns and Ammunition- Main Gun. The major components of the Main Gun are shown in Figure 2-5. The gun is mounted in the turret on trunion pins and stabilized in the vertical plane by attachment to the elevation mechanism. Traverse and elevation motions of the gun are hydraulically actuated and controlled from either the gunner's or the tank commander's control handles. The commander can override the controls at any time. Manual controls are available at the gunner's station. Ballistic computer is operated by the gunner and critical data such as the type of round, cross-in, air temperature, etc. are compensated for in the computation of gun superelevation and azimuth. Stabilization mode is available for target tracking while the tank is in motion.

Ammunition consists of five, standard round configurations, namely; armor piercing, two types of high explosive, anti-personnel and white phosphorus. Storage for 63 rounds is provided in the turret and hull. Once ammunition is loaded into the gun, firing can begin as soon as the loader has moved the "loader's safety switch" to the FIRE position. When a round is fired, recoil energy is dissipated through the recoil mechanism. According to Chrysler data, the approximate recoil time is 0.12 second, while counter recoil is about 0.50 second. The recoil mechanism is a concentric hydraulic shock absorber with an integral compression spring for counter recoil. The hydraulic fluid level in the system is monitored after each firing to ensure an adequate supply.

Machine Guns - The 7.62 mm gun is attached to the loader's side of the main gun. This gun is coaxially aligned for firing, utilizing main gun ballistic sights. It can be operated separately or concurrently with the main gun. Controls for firing are at both the gunner and tank commander positions.

Ammunition (6000 rounds) for the coaxial gun is stored in the turret. A ready box containing 2200 rounds is mounted to the turret wall (loader's side) and feeds through a chute to the gun. An additional 3800 rounds is stored on the floor behind the gunner. Expended rounds are ejected into a storage bag also located on the main gun. A .50 caliber machine gun is mounted on the cupola. This gun is traversed and elevated by manually

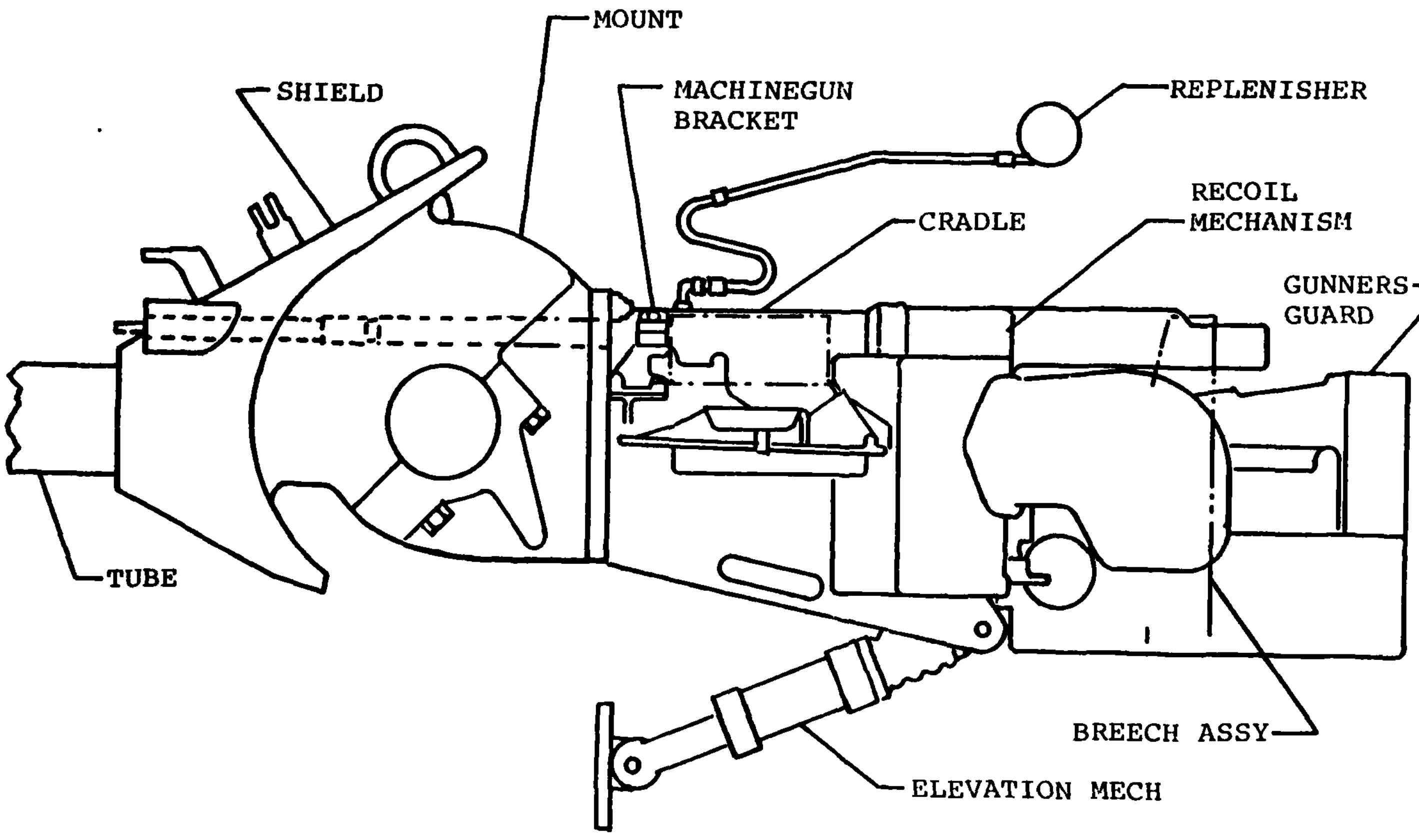


Figure 2-5 105mm Main Gun, Major Components

cranking the cupola for traverse motion and the gun elevation drive for elevation motion. This weapon can be fired only from the Tank Commander's position.

Vehicle motion, induced by the firing of the main 105 mm gun is a function of position and elevation of the main gun/turret. If the main gun is in the nominal position, that is, the barrel directly over the driver's head, the induced primary vehicle motion due to operation of the gun would be in the longitudinal and pitch directions. Similarly, if the main gun position is in a ± 90 azimuth position, the induced primary vehicle motion due to gun operation would be in the lateral and roll directions. For a ± 45 degree azimuth position, the primary induced vehicle motion due to gun fire would be a combination of longitudinal, lateral, yaw, roll and pitch. The contribution in each direction in the above examples is a function of the elevation of the main gun.

Assuming the main gun is in the nominal position, preliminary Chrysler data indicates that the maximum pitch velocity is 5.5°/second attained 1.0 second after gun fire with maximum pitch excursion of approximately 1° attained 0.3 second after firing. The total time duration of vehicle pitch motion due to gun fire is approximately 1.4 seconds.

2.4.2 Sighting and Fire Control System. The M60A3 tank employs a primary direct fire control system, a secondary direct fire control system, an indirect fire control system for the main gun, and a fire control system for the cupola machine gun and the turret coaxial machine gun.

When a target can be seen through the sights, and all systems are functioning, the primary direct fire control system is used. The primary direct sighting and fire control system for the M60A3 consists of the laser rangefinder AN/VVG-2, ballistic computer XM21, ballistics drive M10A3, gunner's periscope M35E1 and the superelevation actuator.

The secondary direct sighting and fire control system consists of the telescope M105E1, telescope mount M114, instrument light M50 (an auxiliary light for illumination of the reticle), a filter box and three filters. The secondary direct fire control system is used when a malfunction precludes the use of the ballistic computer system.

The indirect sighting and fire control system consists of the elevation quadrant M13A3, a control light source, and an azimuth indicator with instrument light. This system is used when the target selected is hidden from direct observation through the fire control optical instruments or for preparing range cards.

The .50 caliber machine gun sighting and fire control system consists of periscope M36E1, periscope mount M119, and instrument light to provide illumination to the periscope reticle.

This sighting system is linked to the machine gun cradle trunnion so that the line of sight moves with the gun when it is elevated or depressed to enable the commander to lay on the target when the tank is "buttoned-up".

The sighting and fire control system for 7.62mm machine gun consists of a portion of the XM21 reticle projector which provides a reticle in the unity-power optical system of the periscope M35E1 to provide target engagement for the 7.62mm machine gun.

Sighting optics were described in Section 2.3. The following paragraphs describe the remaining major components of the sighting and Fire Control System.

2.4.2.1 Laser Rangefinder System. The AN/VVG-2 Laser Rangefinder (LRF) system consists of a Receiver-Transmitter Unit and a Power Supply Synchronizer. The system provides the M60 crew a fast, accurate, line-of-sight target-ranging capability along with a combined high-and-low-power optical system to assist the tank commander in target acquisition, ranging and gun laying. Ranging is accomplished by measuring the time delay between a transmitted pulse of laser energy and the reflected return. The LRF has the capability of storing data on as many as three targets that intercept the laser beam. The stored ranges may be separately displayed using the range return selection switches and LED range indicator on the Receiver-Transmitter control panel. Selected range information is fed into the Ballistic Computer for use in computations for firing at moving or stationary targets.

The Laser Rangefinder is located at the tank commander's station. The Laser Rangefinder optical system is equipped with a low magnification viewing mode for acquiring targets and a high magnification viewing mode for ranging and gun laying. In addition, the optical system of the Laser Rangefinder serves as the commander's primary sight for directing fire from the main gun. The optical system provides a means of introducing azimuth corrections into the pointing of the Laser Rangefinder to compensate for target lead. The Laser Rangefinder's optical system provides means whereby boresight of the Laser Rangefinder, with respect to the main weapon, can be checked and adjusted. Elevation corrections emanating from the computer as well as weapon elevation are introduced into the LRF by rotating it about its elevation axis. A built-in internal test capability is provided to check overall Laser Rangefinder system operation and pinpoint malfunctions to the unit level.

The transmitter-receiver unit contains a transmitter to generate the laser pulses, a receiver for converting the reflected light from the targets to electrical signals, and built-in test circuitry. The unit also contains a selectable dual power 6X-12X telescope.

The commander's control panel is located to the left of the transmitter-receiver. Basic panel controls are: Mode selection, Return selection, Battle Range selection, Range, and Reset and Feed. Each control has associated lighting feedback. LED indicators display the number of returns and the range of the selected return. A Select light indicates a ranging condition that requires the commander to select and transfer one of the returned ranges. A Go light indicates that a range has been automatically or manually transferred to the computer. A malfunction light is provided to indicate when there is a specific malfunction in the transmitter or data processing circuits as a result of improper circuit or logic conditions. The specific trouble area is indicated by a digit display on the range indicator.

The power supply synchronizer contains the data processing circuits for storing range data for the three targets that might be detected, power supplies and the built-in test circuitry.

An auxiliary input to the LRF system is the Laser Control thumb switch on the Gunner's Control Handle. The gunner, utilizing his own optics for sighting, may depress this switch to fire the laser. However, unless assistance is provided by the commander, the returned range will be input to the Ballistics Computer only if the LRF is in "AUTO" mode.

The AN/VVG-2 has an operating range of 200 to 5000 meters. The system has a range accuracy of ±10 meters and accordingly is capable of resolving two targets a minimum of 20 meters apart. The maximum ranging recycle time is 4 seconds. The minimum ranging period, without overheating is 3 per minute sustained or 6 per minute for 2 minutes with 3 minute intervals between each 2 minute ranging period. Battle range is 1200 meters at the gunner's sight and 2000 meters at the laser, which allows for minimum parallax. Boresight adjustment is ±5 mils in both elevation and deflection. Target lead capability is ±36.5 mils.

2.4.2.2 Ballistic Computer System. The XM21 Ballistic Computer System (BCS) provides the computations necessary to aim, track and fire against moving or stationary targets. Utilizing sensor or manually inserted inputs and characteristic constants associated with the selected ammunition type, the BCS compensates for the effects of range, drift, crosswind, horizontal target motion, altitude, air temperature, gun wear, trunnion cant, gunsight parallax and gun jump. Information is processed in analog form and transmitted as output shaft rotations (representing elevation) to the superelevation actuator and ballistics drive and as electrical signals (representing azimuth) to drive the reticle projector of the gunner's periscope and the laser rangefinder reticle. Elevation and deflection signals are also transmitted electrically to the stabilization system. The BCS contains self-test circuitry to check computer system operation and to pin-point malfunctions to the unit level.

Figure 2-6 is a functional block diagram of the XM21 Ballistic Computer System. The BCS consists of the following primary components:

- o Computer Unit
- o Gunner's Control Unit
- o Commander's Ammunition Selector Control
- o Gunner's Ammunition Selector Control
- o Cant Unit
- o Rate Tachometer
- o Output Unit
- o Crosswind Sensor
- o Reticle Projector

The Computer Unit contains DC power supplies, power distribution and filtering circuits, quadrature suppression, system computational and built-in test electronics and output drive circuitry. The circuitry is mechanized on module type printed circuit boards.

The Gunner's Control Unit facilitates BCS power and lighting control, mode selection, manual data insertion and subsystem failure indication. A built-in test mode switch in the front panel permits selection of computer system test mode, normal operation mode, or failure indicating lamp test mode. An internal built-in display in the front panel indicates, by means of lights, whether the ballistic computer system is performing satisfactorily, or, if not, which unit is malfunctioning. Toggle switches are used to select manual or automatic range and crosswind. Potentiometers allow for manual inputs of:

- o Range (20 meter increments)
- o Crosswind (5 mph increments)
- o Jump (0.1 mil increments)
- o Zeroing (0.1 mil increments)
- o Altitude (100 meter increments from -200 to 3000 meters from mean sea level.
- o Air Temperature (10^{o}F increments from -65^{o}F to 125^{o}F)

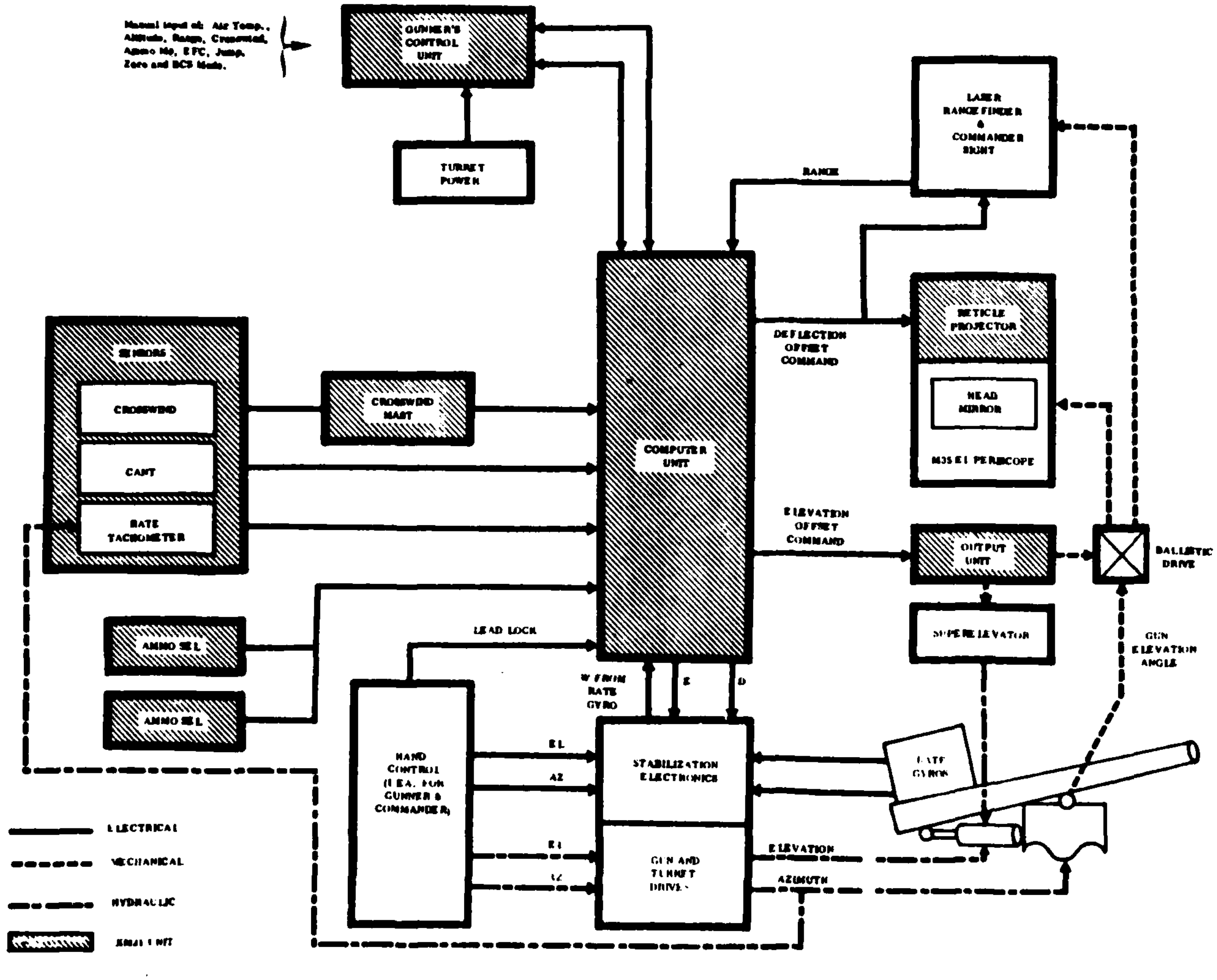


Figure 2-6 XM21 Ballistic Computer System- Block Diagram

2.4.3 Stabilization System. The M60A1E3 incorporates a rate stabilization system, which complements the Weapon System, by increasing target acquisition capabilities and accuracy of fire during periods in which the vehicle is moving. By facilitating effective offensive operation 'on the move', the stabilization system reduces vulnerability to enemy fire.

The stabilization system consists of electro-hydraulic components added to the gun elevation and turret traversing systems (refer to 2.6). The integrated system is designed to operate in a stabilized mode utilizing the stabilization system and in a 'power' mode which does not utilize the stabilization system.

The function of the stabilization system is to space-fix (stabilize) the gun at a desired angular orientation relative to an earth reference plane. This is accomplished by providing azimuth and elevation axis stabilization for the turret and gun respectively. Stabilization is with respect to external angular disturbances caused by vehicle motion. Stabilization does not compensate for changes in target line of sight caused by motion. The commander or gunner must therefore maintain accurate sighting with their respective power controls.

The stabilization system consists of a rate sensor package, control selector assembly, electronics control unit, solenoid valve, traverse servovalve assembly, elevation servovalve assembly, adjustable register assembly, hydraulic filter, anti backlash cylinder, and stabilization shutoff box.

In stabilized operation, the rate sensor package measures angular rates of the gun, turret azimuth, and gun elevation rate. These measured rates are compared with the gunner's (commander's) commanded rates (as determined by the angular position of the gunner's (commander's) handle and measured by the adjustable resistor assembly), and the elevation correction and deflection signals generated by the Ballistics Computer. Comparisons are accomplished by the electronics control unit. Error signals resulting from these comparisons are shaped according to the controller's elevation and azimuth transfer functions and applied as command signals to the servo valves.

Stabilization system power and stabilizer ON/OFF switches are located on the control selector assembly. This unit also contains null potentiometers for control of stabilization closed-loop balance.

2.5 Power Train

The M60A3 Combat Tank power train is comprised of the engine with its associated fuel system, cooling system, air-intake and exhaust system, together with the transmission, universal joint and final drives.

The engine is a twelve cylinder 'V' type, 4 cycle, air-cooled diesel engine manufactured by Teledyne, Continental Motors, type AVDS-1790-2C (RISE).

Engine system characteristics are as follows:

Maximum Gross Horsepower	750 @ 2400 rpm
Maximum Net Horsepower	642 @ 2400 rpm
Maximum Gross Torque	1770 lb. ft. @ 2000 rpm
Maximum Net Torque	1620 lb. ft. @ 1800 rpm
Engine Oil Capacity	22 gallons

Engine controls and indicators include: starter switch, foot controlled accelerator (throttle) pedal with locking mechanism, tachometer/hour meter, speedometer/odometer, engine oil pressure gage, engine oil temperature gage, and a power plant warning light. The power plant warning light illuminates when the engine oil pressure is equal to or less than 13 psi, when the engine oil temperature exceeds 285 degrees F. The hour meter indicates total hours of engine operation. All of these controls and indicators are located in the drivers compartment.

The fuel system stores and supplies fuel to the engine, the personnel heater, and the engine air intake manifold heater. Fuel system equipment consists of two tanks with a crossfeed manifold, electrical fuel pumps located in each tank, mechanical purge pump to clear the fuel lines of air, intake manifold heater for cold weather starting, engine mechanical pump, integral mechanical centrifugal governor controlling the fuel delivery as a function of engine speed, fuel system filters, interlock isolation valve, injector pump which delivers fuel of high pressure to each cylinder and various solenoids and, manual and check valves. Controls and indicators for the fuel system include: a fuel pump shutoff switch, electrical engine fuel shutoff switch, heater master switch, heater HI-LO switch, fuel purge pump, manifold heater control switch, fuel quantity indicator selector switch (left or right), and a mechanical fuel shutoff handle. A fuel quantity gage is also included. Useable fuel capacity for both tanks is 375 gallons.

The engine air intake system consists of two fender-mounted dry type, top-loading air cleaners, two turbosuperchargers, and air intake manifolds with associated manifold heaters. The system is identical for both left and right engine cylinder tanks. Intake air is drawn from either the crew or engine compartment. The air passes through the inlet hose to the air cleaners. Filtered air from the air cleaners enters exhaust-driven turbosuperchargers to compress air into the cylinders through the intake manifold. Manifold heaters are provided for preheating the combustion mixture when starting the engine in low ambient

temperatures. No controls or indicators are provided for the engine air intake system.

The exhaust system has four engine manifolds, one for each group of three cylinders. The engine exhaust passes from the exhaust manifolds to the turbosupercharger, flows around the turbine housing, and through a set of nozzles to drive the turbine wheel. The exhaust pipes direct the exhaust toward the rear grille doors. Here again, no controls or indicators are provided for the exhaust system.

The cooling system consists of two axial-flow fans mounted over the "V" of the engine providing cooling air for the engine and engine and transmission coolers. The cooling system indicators consist of a power plant warning lamp, engine oil temperature gage, and a transmission oil temperature gage. The power plant warning lamp will light when either the engine oil pressure is low or the engine oil temperature transmission oil temperature is hot.

The Detroit Diesel, Allison, GMC CD-850-6A crossdrive transmission is a combination steering, braking and power transmitting unit. The transmission is controlled by means of a steering control, brake pedal and transmission shift lever installed in the driver's compartment. There are two forward speed ranges low (L) and high (H) and one reverse. Steering in neutral causes the vehicle to pivot in place, with the tracks running in opposite directions. The transmission includes a hydraulic torque converter, four planetary gear sets, a steering mechanism and an internally operated mechanical braking mechanism. The input parameter to the transmission is engine torque and the output parameter is transmission torque. Steering control consists of a "T" bar connected to a steering linkage that connects to the steer valve shaft assembly on the transmission. Braking control consists of a single pedal actuating a hydraulic master cylinder coupled to the two slave cylinders that in turn operate wet-disk type brakes on the output shafts of the transmission. A parking brake feature is incorporated into the transmission selector lever and slave cylinders. By depressing the brake pedal while shifting to park (P), a mechanical linkage and cam mechanism causes the slave cylinder to lock in position. To release the brakes, the procedure is reversed. A brake pressure gage is located on the master cylinder to aid in the parking brake operation. The transmission system indicators include a transmission oil pressure gage, a transmission oil temperature gage and speedometer/odometer. Transmission system control is a shift lever allowing the driver to shift the transmission to park (P), neutral (N), low (L), high (H) and reverse (R).

Universal joints are double-journal units that compensate for misalignment of the transmission and final drive. No universal joint indicators or controls are provided.

The final drive is a single-stage speed reduction unit. The final drive gear ratio is 5.08:1. Again, there are no final drive controls and indicators.

2.6 Vehicle Systems

2.6.1 Hydraulic System (Table 2-1). Power to operate the turret and gun control system is primarily hydraulic. There are three modes of turret and gun control: non-stabilized power mode, stabilized mode, and manual mode.

Hydraulic power for the systems is stored in a main accumulator charged to 1225 psi. Recharging the accumulator is accomplished by an electrically operated pump whenever the charge drops below 925 psi. A pressure gage is mounted on the accumulator output to maintain a constant pressure to the using systems.

A POWER switch, located on the Gunner's Gun Control Box Assembly, operates a hydraulic power valve spool solenoid. In the energized position, it allows pressurized oil to flow to the four-way traversing and elevating spools, commander's override spool, auxiliary pressure spool, the superelevation actuator, and deck clearance valve.

A POWER ON indicator light is also located on the Gunner's Gun Control Box assembly to indicate that hydraulic power is available to operate turret and gun hydraulic systems.

2.6.2 Traversing Gearbox Hydraulic Motor Assembly. The traversing gearbox assembly is used to rotate the tank turret. It is normally hydraulically powered and electrically and mechanically controlled. It can also be manually operated using a crank. In the non-stabilized but powered mode, control of the assembly is accomplished by the gunner's power control assembly handles. The commander's handles allow the commander overriding control of the system (otherwise the gunner is in control).

The traversing gearbox also contains a magnetic brake operated by a palm switch on the gunner's or commander's control handle. The brake is used to prevent turret drift and curtail turret drive motion.(See table 2-2)

In stabilize mode, an additional set of electronics and valves provide inputs to the traverse unit. These components tend to maintain the turret azimuth constant regardless of hull motion.

The manual mode is used during unpowered or fine gun laying operation. A crank, connected to the traversing mechanism, is normally locked out but may be operated when the gunner grasps the crank handle assembly and squeezes the release lever. A clockwise turn on the crank, located near the gunner's station, causes the turret to rotate right. The reverse rotation causes the turret to rotate left. The crank will operate the turret at anytime and is not affected by the magnetic brake.

TABLE 2-1 HYDRAULIC SYSTEM DATA

POWER PACK CONTROL ASSEMBLY	
Net Weight	189 lb
GUNNER'S CONTROL ASSEMBLY	
Net Weight	43.25 lb
RESERVOIR	
Capacity	11.25 qt
Net Weight	16.80 lb
ELECTRIC DRIVE MOTOR	
Weight	77.0 lb
Rated Speed (full load)	3,800 rpm
Rated Power	5 hp
Rotation (as viewed from drive end)	Clockwise
MAIN ACCUMULATOR ASSEMBLY	
Weight	72 lb
Type	Floating Piston

TABLE 2-2 TURRET TRAVERSING SYSTEM DATA

AUTO MODE	
Weight	298 lb
Minimum time for power traverse of turret 360°	15 sec
Maximum Azimuth Turret Acceleration Rate	300 mils/sec/sec
Azimuth Slew Rate	0.50 to 400 mils/sec
MANUAL MODE	
Manual Traverse Range	360° cont. rotation
Manual Traverse Rate (tank level)	10 mils per hand crank revolution
Manual Traverse Effort	Mean force 17 lbs applied tangentially to the hand traverse crank

A separate mechanical Turret Lock Assembly, located near the loader's seat, can be used during periods of operation when turret movement is not required. It can not be overpowered by any means.

2.6.3 Gun Elevation Mechanisms. The Gun Elevation actuator is hydraulically powered from the hydraulic system accumulator or by a manual elevation hand pump at the gunner's station. Normal control is through the gunner's control assembly handles or, in the override condition, by the commander's control assembly handle. The palm switches on either the gunner's or commander's control handle must be depressed to gain control of the elevation system. In the normal powered mode, hydraulic power from the accumulator is provided if the Elev/Trav Power Switch on the Gunner's Gun Control Box is in the ON position. (Table 2-3)

The manual elevation hand pump can be used in any mode and does not require palm switch operation.

In the Gun Stabilized mode, a computer system furnishes electrohydraulic signals to the elevation system to maintain constant elevation regardless of hull movement. The elevation system is also furnished a ballistic correction signal from the ballistics computer and superelevation actuator. Elevation is then corrected for range, type of ammunition, and other effects.

2.6.4 Electrical System. The tank electrical and system power equipment consists of 6, twelve-volt batteries to maintain the 24-vdc system, a 650-amp gear-driven alternator and a solid-state regulator. Output current of the batteries is 300 amps, with a 100-amp/hr capacity rating. Additional related equipment includes control switches, power relays, circuit breakers, and a Battery Generator Indicator.

The master (battery) switch energizes a master relay which in turn, provides power from the batteries to the master control panel, slip ring assembly, and fire extinguisher control circuit. When the master switch is in the ON position, all electrical/electronic equipment can be powered by their individual controls, provided the engine is running or the batteries are charged.

If the master switch is in the OFF position, only the Personnel Heater and the fire extinguisher system remain operational. A Master (Battery) Indicator Light on both the Master Control Panel and the Networks Box assembly monitor the POWER ON status.

A battery-generator indicator is located on the Gage Indicator panel. This indicator monitors battery condition when the engine is not operating or the alternator charge rate when the engine is operating.

TABLE 2-3 GUN ELEVATION SYSTEM DATA

Gun Elevating (depession of gun)..........	10° minimum each side of vehicle front centerline to 90° of vehicle rear centerline 0° minimum each side from 90° of vehicle rear centerline to rear centerline
(elevation of gun)..........	20° maximum for 360° of turret traverse
Type of Elevation Mechanism...............	Hydraulic
Rate of Power Elevation of Gun(max).......	4°/sec
Gun Elevation Acceleration Rate...........	660 mils/sec/sec
Gun Elevation Speed.......................	0.50 to 71 mil/sec

Circuit breaker protection is provided on the fire extinguisher/ fuel cutoff and master relay circuits. These automatic reset CB's are located under the turret platform. Other miscellaneous CB's are located within the master control panel and inaccessible to the operator.

Tank exterior lighting consists of standard white light, blackout, and infrared illumination. The headlight group consists of 2 removable assemblies mounted on the front hull. Each assembly has 2 sealed-beam units (white and infrared) and a hooded blackout drive and blackout marker lamp. A pair of tail light assemblies exist with standard and blackout capabilities. Both assemblies provide blackout drive marker lamps. The left light assembly has a standard drive light and stop light. The right assembly incorporates only blackout drive and blackout stop lights.

Lighting controls are located on the master control panel along with a HIGH BEAM indicator light. An automotive type foot dimmer switch is located to the left and below the brake pedal.

Interior lighting consists of a dome light at each crew member's station. Dome light assemblies incorporate dimming and selectable red or white illumination.

2.6.5 Fire Extinguisher System. The primary function of the fixed fire extinguishing systems is to extinguish fires within the engine compartment. The system consists of three charged cylinders, two control head assemblies, three perforated discharge tubes, one time-delay valve, one interior and two exterior control handles, three deck valves, connecting lines, and fittings.

The charged cylinders, fire extinguisher control handles, and related components are located to the left of the driver's seat.

The system operates on a two-shot principal; the first shot discharging one cylinder and the second shot the remaining two. The discharged agent is disbursed through the engine compartment through the perforated tubing. When the interior control handle is actuated, a fuel shutoff solenoid is energized stopping fuel flow to the engine.

There is one portable fire extinguisher in the turret, located under the loader's seat.

2.6.6 Personnel Heater, Ventilation System , and Gas Particulate System. The personnel heater is a self-contained unit located on the right side of the driver's compartment. It supplies warm air to the tank interior.

The heater operates on fuel from the vehicle fuel system but utilizes a separate electrical fuel pump. Heater exhaust is piped overboard through a hole in the hull roof above the heater unit. Heated air is fan-forced through a manifold and flexible duct to an air deflector in the turret area. Control of the heater is maintained by a Heater Master switch, a Heater HI-LO switch, and a Heater ON indicator light all located on the Master Control Panel in the driver's compartment.

A ventilating blower, located in the ceiling of the left turret bustle, provides approximately five changes of fresh air per minute. An ON-OFF switch, on the ceiling behind the commander's dome light, controls its operation. The blower is used to purge the hull interior of noxious gases produced when the guns are fired.

The Gas Particulate System is used to protect crew from breathing contaminated air in the event of a CBR attack. Contaminated air is drawn through a series of filters to remove dust, aerosols, and poisonous gases. The purified air is delivered through the turret slip-ring assembly to the turret crew station. Each station has a thermostatically controlled, electric air heater unit for cold weather operation. Crew members attach their personal face masks at their own station outlet. A control switch and indicator light are located on the Master control panel.

2.6.7 Hull-Turret Inflatable Seal. An inflatable seal between turret and hull is used to make a water tight compartment of the hull/turret interior. During fording operations, a bicycle-type hand pump at the driver's station is operated to inflate the seat to approximately 14 psi. Also included is a bleed valve, gage, and manifold to supplement the operation.

2.6.8 Fuel System. See power train description Section 2.5.

2.6.9 Bilge Pump. The Bilge Pump is used to pump water from the crew areas of the hull during and after fording operations. Control of the pump is achieved by operating a switch on the Master Control Panel. A light is provided to indicate ON/OFF status.

2.7 Crew Station Configuration

A Full Vehicle Crew consists of:

1) Tank Commander (Right Rear Turret)

2) Gunner (Right Front Turret)

3) Loader (Left Rear Turret)

4) Driver (Front Hull)

The M60A3 tank has 3 major component groups which are discussed separately. Those are:

1) Hull

2) Turret

3) Cupola

2.7.1 Hull. This portion of the vehicle serves as an enclosure for the driver and his controls, a housing for the engine and its support systems, the electrical source, and turret support.

The driver's compartment, (forward hull) contains ammunition storage racks (105mm) located along either side of the seat, vision equipment consisting of three (3) periscopes and a night vision viewer that he can install in his overhead hatch cover. A master electrical control panel, gage panel, communications control panel, and miscellaneous indicating devices provide the driver with control over the vehicle's electrical and communication systems as well as allowing him to monitor engine performance. Primary control devices consist of a "T" bar for steering, brake pedal, gear shift, and accelerator pedal. Secondary controls include a hand pump for inflating the turret seal, drain valve control levers, fixed fire extinguisher control, emergency fuel shutoff, and purge pump. Other equipment includes a bilge pump, gas particulate system, personnel heater, escape hatch, etc.

The engine compartment (Rear Hull) houses the engine, air cleaners, fuel tanks, and transmission.

The center hull area contains the batteries that supply the electrical power for the vehicle.

2.7.2 Turret. This section houses 3 crew members, the main armament with its sighting and firing systems, and serves as a structural support for the cupola.

The turret interfaces with the hull through a combination ring gear/ball bearing which allows rotation independent of the hull. A floor suspended from the turret and extending downward into the hull serves as the supporting member for the fighting crew, their seats, ammunition storage racks/boxes, equipment storage, power pack, main relay box, electrical slip ring, and other miscellaneous items. That portion of the turret above the hull supports the main armament, telescope, gunner's periscope, laser range finder, turret traversing controls, ballistic computer system and stabilizer control system. Radio equipment, ventilating blower and other items such as dome lights, storage boxes, ammunition boxes, are also located in the turret. Two seats are available for the commander, one of which is used when his hatch is open, the other when the hatch is closed. The loader and gunner have one seat each.

2.7.3 Cupola. The cupola serves as a protection device for the commander as well as providing him with vision devices and a small caliber automatic weapon.

A combination ring gear/ball bearing joining the cupola and turret allows independent 360° rotation. Vision blocks and a periscope provide the commander with 360° visibility without rotating the cupola. A machine gun, ammunition storage, intercom/radio controls, firing controls, gun elevation system, traversing mechanism and other miscellaneous equipment are also located in and supported by the cupola.

SECTION III

3. TACTICAL ENVIRONMENT ANALYSIS

This section examines the tactical environment in which the M60A3 tank and its crew operates. The extent of scientific analysis performed by the Link study team on this subject has been limited, primarily by the lack of quantitative and qualitative data available. The aspects discussed include:

- o Geographical and terrain conditions
- o Climatic conditions
- o Threats and friendly forces
- o Tactical information

3.1 Geographical and Terrain Conditions

Terrain has always been the overriding condition determining the deployment of armor. In recent wars, both natural and man-made obstacles have dictated the type and extent of armor operation possible. Although some terrain is better suited for tank deployment than others, tanks may be deployed in any part of the world, although numbers may be limited in some areas.

3.1.1 Tactical Considerations. For the tank crew, the terrain presents that part of the environment through which the tank and the crew are moved to a position where they can close on the objective and destroy the enemy. Particular attention has been paid in this study to the terrain characteristics of Western Europe and the continental United States, since almost all of our armor units are located in these areas. Fortunately, for purposes of training, these two areas are quite similar. Both provide areas comprised principally of gently rolling terrain partially covered with forests, with many rivers and lakes. These areas include sophisticated road networks connecting all populated areas, and thus high speed approaches to almost all potential military objectives. The majority of the highway bridges on the North American and European continents will support the M60A3 tank. The M60A3 tank has excellent crosscountry mobility since few natural obstacles presenting a gradeability of less than sixty (60%) or a water depth of less than four (4) feet will stop the tank. Most soils on these continents will support tank traffic although swampland severly limits mobility. Weather variations in Europe and the continental United States present some problems in tank operations, but temperature extremes generally do not affect armor operation. Visibility has in the past impacted heavily on the crews' ability to move and to acquire and engage targets. Recent breakthroughs in the state-of-the-art, however, have vastly reduced this problem. The M60A3 tank with the gunner's and tank commander's thermal viewing systems and the driver's image intensifier permit near daylight visibility under conditions of

limited visibility such as smoke, fog, haze, and rain.

The tank commander and the driver primarily are concerned with evaluating terrain. The tank commander searches for threats, targets, avenues of approach, fields of fire, and likely firing positions. He and the driver attempt to predict areas where threats might be concealed, areas affording cover, mobility, and firing stability. Experienced drivers select optimum routes and firing positions with little or no direction from the tank commander. This leaves the tank commander free to devote his attention to target acquisition and engagement.

While the M60A3 can negotiate almost any type of terrain found in the European continent, various types of terrain have their effects on tank speed, maneuverability and agility. In addition, of course, terrain, cultural and vegetative features vary widely in their ability to provide cover and concealment. As a result, the driver and tank commander must constantly assess the terrain and its ability to minimize tank visibility from areas of likely threat location. They must also constantly assess the effects of the terrain and potential obstacles on the ability of the tank to move to the objective and to maintain its position with respect to other elements involved in mutual support. The tank can cross many obstacles without appreciable effects on speed, while others will slow it significantly, increasing its vulnerability and limiting its ability to provide support for other elements. Some terrain surfaces and obstacles will not slow the tank, but may restrict the ability of the gunner and the tank commander to acquire and engage targets while moving, and the ability of the gunner to load the main gun and maintain the coaxial gun in firing condition. The effects of the terrain on the crew can be profound, until each learns to predict, minimize and otherwise deal with its effects.

3.1.2 Vehicle Mobility Considerations. The mobility of a land vehicle is a function of not only the vehicle characteristics but also the geometry of the ground surface and the physical properties and state of that surface. The geometry of the ground surface depends upon the type of terrain, and for the M60A3, the operating environment is likely to vary from rolling hills and valleys, to flat but uneven ground with gullies, ditches, streams, and rivers. The physical state of the surface will vary from that presented by hard paved roads, to that of unbroken ground with rocks, gravel, sand and dirt, together with assorted vegetation ranging from grass and scattered shrubs to dense foliage and trees. Each of these surfaces can vary as a direct result of climatic conditions, i.e., wet or dry surfaces, mud and swampy ground, and more particularly the presence of snow and ice.

Any vehicle of adequate power to provide the thrust required for propulsion will move across country only if the characteristics of the ground surface are such as to sustain the reactionary forces generated and support the weight of the vehicle.

Vertical and horizontal reaction forces of the ground involved in land mobility are called sinkage, traction, and motion resistance. Sinkage is a function of ground pressure. Horizontal propelling forces produced by the shearing strength of the ground under vehicle action is the maximum thrust the soil can sustain. A part of this thrust is wasted in overcoming motion resistance, and the rest, which remains as a useful force to accelerate the vehicle, to climb a slope, or to pull loads. These forces are defined in terms of the physicogeometrical properties of the soil-vehicle system.

The physical properties of the soil can generally be described in terms of friction and cohesion. Examples of friction type soils are dry sand and cold "sugar" snow. Sand or frozen snow grains are loose and move upon each other with ease, particularly if the grains are not too coarse. If the grains are pressed against each other, friction develops among them and they cannot move, thus offering resistance. In this case,the tractive force increases proportionally to the weight of the vehicle. Examples of cohesion type soils are wet clay and snow. In this case, the tractive force remains constant regardless of vehicle weight. This is due to the existence of cohesive forces which bind soil grains or snow crystals, through capillary action of moisture films and other complex physical phenomena . Moreover, the tractive force required to shear the stickiness of this soil mass is proportional to the size of the surface area in contact with the ground.

As described above (with respect to snow), the moisture content effects soil characteristics. Therefore, ambient weather condition is relevant in analyzing soil characteristics in order to determine vehicle mobility.

It is important to note, at this time, that the vehicle's speed is not governed by the power train alone, but also by the geometry and dynamic properties of the vehicle structure. These factors, in conjunction with the unevenness of the terrain surface, produce vehicle vibrations that impact both crew and vehicle, and may be prohibitive for human endurance and cause fatigue stress of the vehicle structure metals if riding speeds reach certain limits. The average M60A3 combat tank tactical cruising speed is approximately 10 mph, even though the maximum speed of the vehicle is 30 mph. Cruising speeds approaching the maximum limit would cause critical pitching and/or bouncing. Vehicle vibrations depend not only on the characteristics of the suspension system but also on the ground wave. A sinusoidal profile of the ground can be considered when dealing with the vibration analysis of the vehicle, particularly since it has been found that there exists a definite pattern of waviness both on highways and in virgin terrain, especially ground of certain geophysical origin. Experience in sand and snow indicates the existence of the same irregularity, even though it is not visible at first

glance. Thus, the adoption of a typical wave based on the available limited experience could serve the purpose of an evaluation of vehicle vibrations.

3.2 Climatic Conditions

Althcugh the M60A3 tank can operate in a wide range of climatic conditions, crew tasks can change drastically with changes in visibility and area surface conditions associated with weather changes. Changes in visibility, mobility, maneuverability, and agility can have profound effects on crew experience and tank effectiveness. Tank operations over snow, ice, mud, and hard surfaces require significantly different responses on the part of the driver, and require different kinds of planning and tactics on the part of the tank commander. In addition, they can have significant effects on the workload of the entire crew.

The entire crew is affected by changes in weather conditions in anticipating areas of possible threat locations, and in recognizing threats and signs of threat activity, especially in limited visibility and in snow. Drivers in particular are affected by rain, fog, snow, and ice in that choices of routes can change markedly with changes in visibility and surface consistency. Fog is a special problem as it greatly reduces the ability of the crew to move and to observe. By the same token, it offers a degree of security for movement, especially over familiar areas. Thermal sensors do change the tactics employed in fog and other types of limited visibility conditions for both friendly and hostile elements, but fog does pose specific problems for armor operations.

Drivers, and tank commanders rarely have opportunities for learning the way in which the tank operates over snow, ice and mud, particularly in negotiating and crossing slopes. In armored combat, the ultimate success of the tank mission depends largely on the agility of the tank, which in turn depends on the ability of the crew members to select routes which are consistent with the requirements of the mission, and within the capabilities of the tank. It is also dependent on the ability of the driver to exercise control for maximum speed, maneuverability, and safety for maximizing firing accuracy, and use of cover and concealment.

3.3 Threats and Friendly Forces

The primary function of the main battle tank is to support the movement of friendly elements in taking various military objectives. This function includes the destruction of a variety of threats, the most important of which are other tanks, weapon systems, and emplacements which threaten the tank itself. Many significant threats operate on the surface of the battlefield, but helicopter threats are of extreme importance because of their ability to make overhead approaches and rapid use of the cover and concealment afforded by the terrain and by various

natural and cultural features of the terrain. Ordinarily, tanks destroy threats by direct engagement, using weapons, or tactics and methods of engagement appropriate to the specific threat and mode of threat deployment. As a result, the tank crew must be able to discriminate, to the maximum extent possible, among various threat types and modes of threat deployment. Tanks, trucks, personnel, artillery emplacements, helicopters and ground-attack aircraft require different kinds of ammunition and different kinds of engagement methods. Tank crews are familiarized with the threats expected to be encountered in possible future wars, and with the characteristics of those threats relevant to their detection, identification, review and engagement.

The M60A3 will encounter eight general types of threats, each having significant implications for crew performance..

(1) Tanks - Tanks are the most lethal threat to the M60A3 because of their mobility, fire power, and armor protection. Tanks are generally equipped with high-velocity guns firing chemical and kinetic energy rounds which can defeat the M60A3. However, the accuracy of some threat tanks is degraded at long range by the lack of precise range finding capabilities. Some threat tanks are less agile than the M60A3, but the capabilities, numbers, and deployment of these systems make their destruction at the longest possible ranges vital to the success of the M60A3.

(2) Artillery - Mobile artillery systems are less of a threat to tanks than are other tanks, since they lack the tank's maneuverability. Most mobile artillery pieces do not have rotating turrets, and though they have great fire power, they are rarely used for direct fire against tanks. They may be used for direct fire defense of objectives attacked by the M60A3. Their positions must be predicted from the analysis of the terrain, and the tactical situation, and their fields of fire avoided whenever possible. Anti-aircraft artillery (AAA) tends to be more mobile than indirect fire systems, but AAA rounds fired by these systems are not especially lethal to the M60A3. The lethality of anti-aircraft artillery systems is in their ability to engage and destroy the scout and attack helicopters furnishing battlefield intelligence and direct fire support to the M60A3. Since armed helicopters can engage and destroy threats which the tank cannot see, systems threatening the armed helicopter are direct threats to the tank itself. In situations where the tank is faced by a variety of threats, anti-aircraft threats rate with tanks as priority targets.

(3) Lightly Armed Vehicles - Additional threats to the M60A3 and to the missions in which it will be employed

are vehicles designed to carry troops and to perform reconnaissance and fire support functions. They are highly mobile, but are protected primarily against anti-personnel weapons such as airburst artillery, small arms and machine gun fire. Some of these vehicles carry mortar or anti-tank guided missile systems and are thus especially important to the M60A3. Their agility makes them hard to engage but also degrades their effectiveness as anti-tank weapons. Stationary, they are good, high-priority tank targets; moving, they are most effectively engaged by airborne systems such as armed helicopters and fixed-wing attack aircraft.

(4) Fixed Emplacements - Fixed artillery positions usually provide indirect (non line-of-sight) fire support, but may engage tanks and other assault elements by direct fire. Bunkers and other fortified positions also pose serious theats to the M60A3 by firing tube and missile systems from protected areas. These emplacements, if they are well prepared, are hard to locate until they fire, and must be detected through careful analysis of the terrain and the situation. Potential fields of fire must be predicted and avoided where possible, especially if the enemy has time to prepare fixed defenses. Bounding over-watch can also be effective in revealing these threats when the exposed moving element is engaged.

(5) Personnel - Individual soldiers can be extremely lethal to the M60A3, particularly when equipped with anti-tank guided missiles. Even troops with simple weapons can be lethal when close to the tank, and concealed by areas masked from the view of the crew. Mutual support among tanks, artillery, and mechanized infantry minimizes the effect of personnel threats provided effective search and support procedures are followed. Troops firing small arms from cover can force tanks to close hatches, increasing their vulnerability by degrading crew visual contact with the area, and by enlarging the size of the tank's blind spots. Troops with grenades and/or explosive charges can also be significant threats, since they can damage tank treads, immobilize the turret, and start fires in the engine compartment if they are permitted to approach the tank.

Personnel firing anti-tank guided missiles (ATGM) at the tank must be, currently, in visual contact with the tank during the missile flight. A crew seeing a missile launch can disrupt the firer's launching performance by firing in his area, if they are aware of the method of engagement used by ATGM elements. In some cases the missile is guided from some distance

to one side of the launcher; firing to the left or right of the launcher can destroy the effect of the ATGM.

(6) Mines - When permitted by time and situation, anti-tank mines are placed in areas likely to be used by the M60A3. Roads, fields and logical routes that may be mined must be avoided, unless there is assurance that the areas are not mined, or that the mines have been destroyed. Sometimes obvious routes are mined to channel the tank into less desirable alternate routes which are also mined, or sighted in by artillery. When mines are detected, they are neutralized by exploding them, or by removing them. When time permits, the mined area and lanes through the area are marked by engineers.

(7) Helicopters - Armed helicopters are major primary threats to the tank. The helicopter can make the same use of cover and concealment as the tank, but is infinitely more flexible in its ability to approach and attack from almost any direction. Helicopters tend to be channeled by the terrain and the deployment of friendly elements, but their approach is harder to predict than that of ground elements.

The M60A3's best defense against helicopters armed with anti-tank guided missile systems is in the support of flexible anti-aircraft missile and artillery systems which, in normal operations, can keep the armed helicopter away from the main battle area. The M60A3 can also defend itself from armed helicopter attacks by means of smoke, and with the main gun and the commander's cupola-mounted machine gun. It must be noted however, that anti-helicopter gunnery requires exceptional skill. Normally, helicopters are exposed only for very short periods, except during the flight of missiles controlled from the helicopter.

Scout helicopter and other observation aircraft are also important threats to the M60A3, because they can direct armed helicopters, attack aircraft, artillery and other tanks in attacking the M60A3. Ideally, these threats will also be neutralized by anti-aircraft artillary support or by attack aircraft, but will occasionally be engaged by the M60A3. They are somewhat more difficult to destroy than the attack helicopter because they tend to operate at greater slant ranges.

8) Attack Aircraft - Fixed-wing, high performance attack aircraft carrying missiles and bombs are also significant threats to the M60A3. Many ground attack delivery systems require the aircraft to perform a stabilized dive for an appreciable period of time,

during which it is vulnerable to anti-aircraft fire. Some systems can be directed by ground or airborne observers reducing the vulnerability of the delivery aircraft, making the delivery aircraft, the ground observer and the airborne observer prime threats to be engaged by whatever means available. The main gun and the .50 caliber machine gun are the most effective M60A3 systems for engaging attack aircraft, but effective engagements require very high levels of crew skill. The M60A3 primary defense against attack aircraft is in the support of anti-aircraft artillery and air-to-air weapon systems, coordinated through the tactical communications network.

The M60A3 crew will always operate as a part of a larger tactical force consisting of at least one other tank, but most often, with an entire tank platoon, and with the support of airborne, artillery, infantry and other elements. Most of these elements are not visible to the crew, but interact through the communications net, and through the visible effects of support weapons in the battle area. Adjacent tanks are frequently visible; the position, movement and engagement modes being employed by those tanks are crucial to the crew in performing in complete coordination. Ideally, tanks in a section move alternately, with one tank covering the other and providing security for it during periods of exposure. At least one tank must be seen by each crew to permit training in section tactics.

Crews are trained to recognize other friendly vehicles and elements. In the European environment, this includes friendly elements from any allied country. In many tank operations, crews will have to distinguish accurately among threat and friendly forces through the discrimination of vehicle silhouettes, modes of deployment and employment and through the recognition of weapon effects. In many tank operations, crews can assume that any vehicle to the front is a threat, but each commander must be proficient in distinguishing friendly and hostile elements.

3.4 Tactical Information

Information about the mission, deployment of threats, terrain, weapon and the deployments, availability and capabilities of friendly supporting elements, and systems is available to the M60A3 crew from a number of sources. The amount and accuracy of information available at any given time is dependent on the situation. In general, ground and airborne reconnaissance elements and other combat units in contact with the threat provide information which is used in defining the mission and the

way it is to b⌣ conducted. Tactics, ammunition loads, likely routes to the objective, threat types, possible fields of fire, obstacles to movement, available cover and concealment, terrain surface characteristics and the availability of reconnaissance, engineer, and fire support are all defined to the maximum extent possible prior to a mission, and updated as required throughout the mission.

A great deal of information is provided during oral pre-mission briefings. The radio is also used heavily, within the limits imposed by security requirements. The crew itself acquires tactical information during its operations, and reporting of events by individual crew members is an important part of the crew's skill in real-time interaction.

The threat takes many forms: the size of enemy, whether it be an individual tank or a large armored force - the composition of the enemy, whether it be dismounted infantry, tanks, or aircraft - the location of the enemy, whether he is occupying a dominant portion of the battlefield or is in a very vulnerable position - whether he is fast-moving and difficult to destroy or is stationary and presents a target which is easy to engage. The sophistication of the enemy with respect to his means of support such as artillery, air, engineers, nuclear and biological weapons is important. Such general information about the enemy is of vast importance. However, the more detailed information about the enemy's capabilities available, the better the opportunity to destroy him. Of equal importance is a knowledge of the enemy's limitations. Do his tanks have power in their turrets or do they have to be operated manually? Is he capable of firing his tank while on the move, or must he halt? More difficult to achieve than a knowledge of the enemy's capabilities and limitations is a knowledge of his intentions. Today's potential enemy has a mechanized army which has us greatly outnumbered in tanks and other mechanized vehicles. He has in his tactical doctrine the philosophy of attacking in mass, and closing on his enemy as rapidly as possible. This concept is taught in the belief that when our forces are closed on rapidly, we will be overrun and become ineffective. To overcome this, tank crews must shoot rapidly. With the proliferation of anti-tank guided missiles (ATGM) in the hands of individual soldiers, it becomes even more important that all targets be engaged with increased speed. Since the potential enemy has the capability to fight a nuclear, biological or chemical (NBC) battle it is imperative that tank crews conduct training wearing NBC protective equipment. Enemy artillery, mortars and other indirect fire weapons present a threat to the tank crew in battle. Although vision, and consequently target acquisition, is impaired, it is most important that the crew be capable of engaging the enemy with all hatches closed (buttoned up).

The potential enemy in a mid-intensity combat environment is capable of gaining local air superiority. It is therefore necessary that tank crews be capable of engaging high performance

aircraft and helicopters. Air defense support for tank units is usually available to provide some protection from high performance aircraft, but with the proliferation of helicopters on the modern battlefield it is very important that tank crews be trained to identify and engage enemy helicopters. The main gun may be used to a limited degree against slow moving aircraft, but the commander's M85 machine gun is the principal weapon utilized. All tank commanders must become proficient with this weapon for engaging enemy helicopters.

Prior to a mission, certain vehicle information is essential. The crew must analyze the assets available to help them to perform their mission. The conduct of pre-combat checks by the tank crew should indicate that all systems are ready for combat and that proper ammunition is stowed and loaded as required with the proper mix of types of ammunition designed to engage any possible targets. Fuel and lubricant level information together with spare parts availability is also vital knowledge required prior to any tactical operation. The crew should also have available to it, any information on the enemy, particularly on the type of targets which can be expected. The crew should also have received all available information on the friendly situation, such as where the tank will be in the formation in relation to other tanks in the platoon, company, or larger force, what fire support will be available from adjacent or supporting forces such as mortars, artillery, air cavalry, tactical air, nuclear, or other special weapons, and whether infantry or engineers will be available to remove mines or other obstacles, plus any other type of support either scheduled or on call to assist the tank crew, must be known. Tactical information continually changes, requiring the crew members to constantly update their analysis of conditions as this will impact their ability to effectively operate as a coordinated tank crew.

Other tactical information concerning the location and size of enemy threats is directly available to the crew members by means of careful scrutiny and evaluation of the surrounding terrain. While enemy threats will normally use all available cover and concealment, their presence may be indicated by tell-tale signs of activity that show up as 'movement' or changes in scene content and that are very easily detected by the human eye. These signs may include the movement of foliage, the glint and reflection of sunlight from smooth reflective surfaces, or the presence of smoke or dust clouds. A more thorough analysis of this type of information is presented in section 4.2 that deals with target detection.

To some extent, aural cues will accompany many of the visual cues, especially in the case of close-proximity threat activity and particularly in the case of incoming rounds and small arms fire. In many instances the aural cue may be the primary cue in alerting the crew to an immediate engagement or requirement for a defensive maneuver, as in the case of an attack by choppers flying NOE missions, or unknown gun emplacements.

SECTION IV

4. MISSION/CREW TASK/CUE ANALYSIS

The M60A3 tank crew consists of four individuals, working as an integrated team. Each individual has his own specific tasks and responsibilities within the team. Crew efficiency and the ultimate effectiveness of the team as a weapon system depends as much on the articulation of their individual responsibilities as on levels of individual skill. Each member of the crew interacts with each other, with his own systems and equipment , and with the tactical environment in which the tank is employed. Individual skill development depends on interactions with equipment at the individual crew stations, but the development of even minimal crew skills depends heavily on individual and crew interactions with the tactical environment.

The tactical environment in which the M60A3 tank is expected to operate has been analyzed, together with the kinds of missions in which it is expected to be employed. Environmental information, important in the development of crew interaction skills, has been identified for possible representation in the crew interaction simulator. Information about the environment comes to the crew in many ways. The tank commander is usually briefed prior to a mission, and he has available maps,and occasionally, photographs of the mission area. He also maintains constant communication by radio, visual signals and personal contact with adjacent and supporting elements. In addition, he briefs the crew on the current situation and keeps them up to date concerning significant changes in the situation and mission.

During the mission, the tank commander and loader maintain visual surveillance of the battle area from their open-hatch positions. When the situation demands, the tank commander operates with his hatch cracked, to provide a good visual field of view, with good cover from overhead artillery bursts. During these periods, the loader may close his hatch, using his unity power viewing device for area surveillance. The gunner searches the terrain with his perisocpe and with his unity-power window. His field of view is severely limited, but the magnification in his periscope makes it possible for him to examine areas of potential threat deployment for targets and signs of hostile activity. He is also able to use his powered optics to assist the driver in evaluating possible obstacles which the driver cannot, without magnification, see from his position.

The driver's position in the hull provides him with a good view of the situation to his immediate front, but his field of view is constrained by the attitude of the tank, the position of the fenders, the front slope, and the turret. Even so, using his vision blocks, the driver has the capability of examining and evaluating terrain and obstacles within the first hundred meters

or so forward of the tank. He is also capable of seeing some distance ahead (terrain permitting) and can sometimes detect targets and signs of activity which the rest of the crew might miss. His position is also advantageous in sensing and adjusting fire, since he tends to be beneath the obscuration produced by the firing of the main gun. Since the driver's primary responsibility is in moving the tank from place to place, in maintaining as low a silhouette as possible and in keeping the turret as stable as possible for searching, sighting and firing, his primary interest is in the terrain within the first two to three hundred meters to the front. The tactical situation and the mission define what he must do; the area to his front dictates how he must do it.

Each member of the crew is aware of the responsibilities of each other member of the crew. As a result, each uses his own position and systems to facilitate the tasks of each other crew member in optimizing tank performance. Crew members in the turret contribute to tank mobility, agility and concealment by providing information to the driver, which is difficult for him to acquire by himself. In turn, the driver moves the tank in such a way as to minimize distractions and disturbances in loading, sighting, firing and sensing. Each member of the crew, in effect, has defined points of contact with the tactical environment, and a different effect on it, but ultimately, each has the same objective: the optimization of the tank in its assigned missions.

Any examination of tank crew missions must recognize that although individuals are trained to become a part of the crew and that a well integrated crew is required in order to operate the tank, the tank is not employed by itself. All proper tank missions require that the individual tank be employed as a part of the tank section, the tank platoon, the tank company, etc. Offensive, defensive and retrograde missions are given to tank units, not individual tank crews. Individual tanks are maneuvered by section leaders or platoon leaders. This direction usually includes the general direction for the tank to move and the designation of a specific target for the tank crew to engage. Whether the tank crew is employed in an offensive or defensive operation, it is normally assigned a sector of responsibility, usually in an arc of approximately ninety degrees (90°). When an offensive mission has been assigned to the tank platoon, and the platoon is moving in a column formation, each of the five tanks will be given a sector of surveillance to the front, right or left flank or to the rear. If the platoon is deployed in a line formation, the three center tanks will be assigned sectors to the direct front, while the two other tanks will be responsible for protecting each flank if they are both exposed. Tanks normally fight with infantry as part of a combined arms team, with the primary mission of the tank is to destroy enemy tanks. The missions assigned to tank units therefore, are usually oriented toward the destruction of enemy forces rather than upon the seizure or retention of terrain.

However, tanks may be deployed to assist infantry forces in the accomplishment of terrain-oriented missions.

4.1 Mission Profiles

Tank missions fall into three basic categories. These are 'offensive', 'defensive', and 'retrograde'. Tanks rarely, if ever, operate as individuals and rarely without the support of infantry, artillery and airborne elements. Thus the complete tactical environment of the tank includes the terrain, the weather, the mission, threats and other friendly supporting, or supported elements. The impact of the environment on the crew changes somewhat with the type of mission, but in all missions, visual information is of special importance. For this reason, special attention has been given in the mission analysis to the crew's use of visual information in learning effective interactive skills.

4.2 Target Search and Recognition

The entire M60A3 tank crew is responsible for surveillance, target detection and target recognition. The tank commander is in the best position to detect targets, but when the tank is not in contact with the enemy, and when contact is not imminent, the loader also has a major responsibility for surveillance. Both the loader and the commander operate with their heads out of the hatches whenever possible, to facilitate the detection of targets and the recognition of signs of target activity. During periods of contact, the tank commander searches with his head out of the hatch as long as small arms and artillery fire permit, moving to the "popped" hatch and closed hatch positions as the situation demands. The loader moves into position for loading, inside the turret when contact becomes likely, relinquishing his search area to the tank commander. When the crew operates in a nuclear, biological or chemical warfare environment, each crew member searches through his unity-power or magnified vision devices. Again, when contact is imminent, the loader must turn over his search area to the tank commander.

All tanks in a unit (section, platoon, company) provide mutual surveillance and in most combat operations further support is provided by airborne elements, forward observers and supporting infantry units. Mutual support is especially important in buttoned-up operations, because of the severely limited fields of view available to each individual crew member.

Targets are rarely detected in combat as distinct, recognizable shapes, because they and the detector make every attempt to remain concealed and unrecognizable for as long as possible.

Target positions are frequently predicted from intelligence information, and from analysis of the characteristics of the terrain. Specific targets are detected by searching suspected areas for signs of activity. Moving vehicles make heat waves,

dust and exhaust smoke and, if they move through vegetation, they cause the foliage to move. Surveillance of an area over a period of time can also lead to target detections, where day to day changes in the terrain are noted. Glint frequently gives away a position, when sunlight reflects off glass, or other smooth surfaces. Thermal sensors are used during the day, at night, and in periods of limited visibility to reveal heat sources otherwise concealed by smoke, dust, haze, or foliage.

Movement is one of the most significant aids to target location, and frequently leads to detections, whether it is the actual movement of a vehicle or of foliage in contact with the vehicle. Weapons firing is also an important cue, and can provide information about target type as well as location.

Targets are usually first sensed by observing signs of target activity. When a crew member sees a target or a possible target indication, he alerts the entire crew, providing information about the kind of target or activity seen, its location and its approximate range. If it is feasible, the gunner will slew the turret to the target area so that he can search with his periscope or thermal sight, but, depending on the situation (extreme target range, or low probability of target presence), he may continue to search in his own primary sector while the tank crew commander searches the suspected area more closely. The tank commander searches primarily with his binoculars because they permit him to rapidly survey his entire area. He may also search the designated area with the thermal sight, the rangefinder or the periscope, but this requires him to move into the cupola losing visual contact with most of his area of responsibility.

Once a target is detected, it must be identified and evaluated with respect to its implications for the tank and its mission. At long ranges (beyond 1200 meters or so) some type of powered optical instrument is required for positive target identification, but in many situations, any target detected to the front can be considered hostile and subject to engagement. In other situations, as in the highly fluid battlefield anticipated in central Europe, the crew will have to take great care in discriminating between hostile, U.S., and other friendly vehicles and elements.

Vehicular targets are recognized by characteristic visual patterns which reveal turret, gun, suspension system and other features. Beyond 1000 meters, most physical characteristics differentiating one tank from another, or one vehicle from another, are not distinguishable to the unaided eye even under good viewing conditions. However, wheeled vehicles can be distinguished from tracked vehicles at extreme ranges (3,000 meters). Haze, target perspective and the use of cover by the target changes these capabilities drastically.

4.3 Battle Conditions

The primary mission of the main battle tank is to move toward an objective, supporting the movement of elements responsible for taking and occupying the objective. In this mission, the tank detects, engages, destroys or neutralizes threats to the maneuver at as great a range as possible. Since most objectives are defended in some degree of depth, the tank must be prepared to find and destroy threats enroute to the objective, by anticipating threat locations and by detecting and evaluating minimal cues to actual threat location and type. The lethality of the weapon systems which the M60A3 can be expected to encounter make early detection, acquisition and engagement crucial, and rapid and accurate crew coordination an absolute necessity.

Conditions under which the M60A3 operates will place a high workload, and a high level of stress on each member of the crew. Some battlefield operations will be conducted with the driver's, loader's and tank commander's hatches open, but friendly supporting artillery, and fire from hostile ground and airborne elements will make it necessary for the crew to operate, in the most crucial parts of the mission, with hatches closed. Operations are also anticipated in nuclear, biological and chemical environments which will force the crew to operate with hatches closed and in protective masks. Closed hatches will severely limit visual contact with the battlefield and with adjacent friendly elements, with protective masks further degrading visual capabilities. Major effects will be on the tank commander and the driver, who must make continuous and complex visual discriminations throughout the mission. The driver's performance degradation using vision blocks instead of direct viewing is less than that for the tank commander, since his position between the fenders and beneath the turret significantly limits his head-up visibility at all times. The tank commander's cupola vision blocks severely constrain his vertical field of view, and his optical sights limit the size of the area he can search readily. All of these conditions force the crew to maintain visual and radio contact with adjacent units and supporting elements providing mutual surveillance whenever possible. They also force the crew to respond rapidly and accurately to events taking place in the battle area.

4.3.1 <u>Engagement Frequency and Duration</u>. As the M60A3 moves toward its objective, it will encounter targets to be engaged and destroyed. The overall situation will determine the types of threats encountered, their relative lethality, and the methods of engagement chosen. Frequently, objectives are within visible range of the line of departure, because the line of departure is defined in part by the effective range of the weapons defending the objective. As a result, depending on terrain and visibility, the mission of a given tank may extend for no more than 2 or 3 miles, with no more than 8 or 10 individual engagements. Most engagements will last from a few seconds to a few

minutes. Those lasting for more than four or five rounds of main gun fire urgently require some kind of external support, to allow the tank to maintain its momentum. Once an attack or any armor movement stops, it must be restarted immediately, or the entire tactical situation must be revised for defense or for a retrograde movement.

A tank moving in an attack can expect to encounter a variety of threats. The crew must be prepared for a variety of engagements against armored and lightly armored vehicles, fixed defensive emplacements, troops and aircraft. The M60A3 carries enough ammunition for thirty or forty individual engagements over a period of several hours, as it moves from one objective to another. Crew fatigue resulting from extended operations is an important factor in tank effectiveness and the effects of fatigue need to be alleviated through the development of the highest levels of individual and crew skill possible.

The variety of engagements possible during any given tank mission, and the many methods of engagement available to the crew make the M60A3 tank the most flexible and adaptable tracked weapons system available. Table 4-1 is a summary of the conditions under which the M60A3 may have to fight, and of the methods of threat engagement available to it in performing its assigned missions. Tables 4-1 through 4-5 list the variety of engagement situations in which the crew must be proficient.

Table 4-1 combines gunner and tank commander tasks in the employment of tank fire control and weapons systems. Checkmarks indicate specific engagement skills employed against both stationary and moving targets. With the exception of range card engagements, each must be accomplished with the tank itself stationary in both stabilized and unstabilized mode.

Table 4-2 depicts 55 distinct engagement situations. Target and vehicle motion create 199 situations in which the entire crew must be proficient in the basic employment of fine control instruments, main gun, and coaxial and .50 caliber machine guns.

Table 4-2 is a matrix of target types and weapons to be used for successful engagements.

Table 4-3 represents an additional family of skills required by the gunner, commander, and loader in allocating weapons to targets, and by the commander in assigning target priorities and coordinating sequential or simultaneous threat engagements.

Table 4-3 lists certain required skills for the selection and employment of available ammunition.

TABLE 4-1 COMBINATIONS OF TANK FIRE CONTROL AND WEAPON SYSTEM UTILIZATION IN M60A3 ENGAGEMENTS

	MAIN GUN		COAXIAL WEAPONS SYSTEM		COMDR'S WEAPON SYSTEM		LOADERS	AUXILIARY FIRE CONTROLS	
	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION	WEAPON SYSTEM	RANGECARD TO DIRECT FIRE	RANGECARD
COMDR									
LASER RANGEFINDER	X	X	X	X				X	
COMDR'S WEAPON SIGHT (3X) (DAY)					X	X		X	
COMDR'S WEAPON SIGHT (NIGHT)					X	X		X	
COMDR'S THERMAL SIGHT (DAY USE)	X	X	X	X				X	
COMDR'S THERMAL SIGHT (NIGHT USE)	X	X	X	X				X	
GUNNER									
GUNNER PERISCOPE (DAY)	X	X	X	X				X	
GUNNER PERISCOPE (NIGHT)	X	X	X	X				X	
GUNNER THERMAL SIGHT (DAY)	X	X	X	X				X	
GUNNER THERMAL SIGHT (NIGHT)	X	X	X	X				X	
GUNNER TELESCOPE SIGHT	X	X	X	X				X	
GUNNER INFINITY SIGHT			X	X				X	

TABLE 4-2 ENGAGEMENT OF TARGET TYPES

	MAIN GUN		COAXIAL WEAPONS SYSTEM		COMDR'S WEAPON SYSTEM		LOADERS WEAPON SYSTEM	AUXILIARY FIRE CONTROLS	
	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION		RANGECARD TO DIRECT FIRE	RANGECARD
TANK	X	X						X	X
TRUCK	X	X	X	X	X	X	X	X	X
ARMORED PERSONNEL CARRIERS	X	X			X	X		X	X
CHOPPER (LOW PERF. AIRCRAFT)	X				X	X	X		
HIGH PERFORMANCE AIRCRAFT	X				X	X			
TROOPS	X	X	X	X	X	X	X	X	X
MACHINE GUN	X	X	X	X	X	X	X	X	X
ANTI-TANK (ATGM'S, ETC.)	X	X	X	X	X	X	X	X	X
FORTIFICATIONS, BUILDINGS, ETC.	X	X	X	X	X	X	X	X	X

TABLE 4-3 M60A3 WEAPON SYSTEM AMMUNITION AND ITS EMPLOYMENT

	MAIN GUN		COAXIAL WEAPONS SYSTEM		COMDR'S WEAPON SYSTEM		LOADERS WEAPON SYSTEM	AUXILIARY FIRE CONTROLS	
	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION		RANGECARD TO DIRECT FIRE	RANGECARD
SABOT (APDS)	X	X						X	
HEAT (HIGH EXPLOSIVE ANTI-TANK)	X	X						X	X
HEP (HIGH EXPLOSIVE PLASTIC)	X	X						X	X
APERS (BEEHIVE)	X	X						X	
APERS (BEEHIVE TIME)	X	X						X	
W P (WHITE PHOSPHOROUS)	X	X						X	X
.50 CALIBER (COMDR'S WPN)					X	X		X	
7.62mm (COAX WPN)			X	X				X	
7.62mm (LOADER'S WPN)							X	X	

TABLE 4-4 RANGE CHARACTERISTICS OF AMMUNITION TYPES

	MAIN GUN		COAXIAL WEAPONS SYSTEM		CMDR'S WEAPON SYSTEM		LOADERS	AUXILIARY FIRE CONTROLS	
	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION	WEAPON SYSTEM	RANGECARD TO DIRECT FIRE	RANGECARD
0-200M BEEHIVE IS BORESAFE UP TO 200M			X		X		X		
0-900M COAX & LDR'S WPN			X	X			X		
0-1100M HEAT BATTLESIGHT	X							X	
0-1600M APDS BATTLESIGHT AND FOR RANGING WITH CALIBER .50 TRACER	X				X	X		X	
0-2250M RANGING WITH CALIBER .50 (ARMOR PIERCING INCENDIARY TRACER)					X	X		X	
0-1200M HEP & WP-USE GUNNER'S PERISCOPE	X	X						X	
1200 - 3200M HEP & WP-USE GUNNER'S TELESCOPE		X						X	
0 - 4400 RANGEFINDER (LASER)		X						X	
0 - 4400 TELESCOPE HEAT RETICLE		X						X	
0 - 3600M TELESCOPE HEP RETICLE (ALSO WPN)		X						X	
0 - 2800M TELESCOPE APDS RETICLE		X						X	

TABLE 4-5 RANGE/EFFECTIVENESS OF M60A3 WEAPONS SYSTEMS

	MAIN GUN		COAXIAL WEAPONS SYSTEM		COMDR'S WEAPON SYSTEM		LOADERS	AUXILIARY FIRE CONTROLS	
	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION	BATTLESIGHT	PRECISION	WEAPON SYSTEM	RANGECARD TO DIRECT FIRE	RANGECARD
COAX AND LDR'S WPN									
NEAR 0 - 300m			X	X			X	X	
MEDIUM 300 - 600m			X	X			X	X	
FAR 600 - 900m			X	X			X	X	
COMDR'S WPN									
NEAR 0 - 800m					X	X		X	
MEDIUM 800 - 1600m					X	X		X	
FAR 1600 - 2250m					X	X		X	
MAIN GUN									
NEAR 0 - 1100m	X	X						X	X
MEDIUM 1100 - 1600m	X	X						X	X
MEDIUM FAR 1600 - 2200m		X						X	X
FAR 2200 - 4400m		X						X	X

Each type of round, which has its own characteristics, must be understood by crewmen skilled in selecting appropriate types of rounds for specific engagement situations. Major characteristics that determine optimum employment of ammunition types are listed in this table. In certain cases, selection of given ammunition for use at a given range limits the crew to a specific fire control instrument or engagement mode.

Each weapon system is optimally employed within specific range limits. When a target appears, the commander must determine specific weapon(s) allocation based on target type and range.

In addition to their being proficient in the tasks listed in Tables 4-1 through 4-5, the crew must be capable of performing these listed tasks efficiently under various visibility conditions (clear days, nights, rain, snow, fog, and smoke associated with battlefield conditions). The crew must also be capable of operating efficiently in an NBC environment, wearing protective equipment, for extended periods of time in the closed-hatch mode.

The variety of engagements in which M60A3 crews must be proficient, and the length of time they could be committed to offensive and/or defensive missions requires extensive training in conditions anticipated for M60A3 employment. Few opportunities exist for overlearning in individual tank crew tasks, or in crew interaction. The development of combat proficiency requires extensive use of synthetic training media for practicing tasks which would otherwise require prohibitive amounts of terrain, fuel, targets and ammunition.

4.4 Crew Task Analysis

The M60A3 is manned by a crew of four; each responsible for a set of individual tasks, but more important, each responsible for providing inputs needed by each other member of the crew and for responding instantly to the requirements of each. The tank, its relationships with other friendly elements and the battlefield environment in which it operates places require-

ments on the crew not required in other weapons systems. The effectiveness of the tank and its survival on the battlefield depend more on individual skills and on interaction within the crew than any other system, largely because many of the crew's most critical and difficult functions have to be performed in very short time intervals, and under very stressful conditions. The tasks required of combat-ready M60A3 crews were analyzed, to identify the most critical crew interaction skills, so that concepts could be developed for a synthetic replacement for the training of these skills. Current training systems depend on the use of the operational tank itself for crew interaction training; but the complexity of individual activities, the effect of crew training on the terrain and the cost of fuel, targets, ammunition and other facilities are all prohibitive when utilized to the degree required for effective crew training.

The primary mission of the M60A3 tank is to attack and destroy threats to the movement of friendly forces on the battlefield. This mission is accomplished by means of movement and fire, using a combination of systems and techniques designed to meet and neutralize a variety of threats under a wide range of circumstances. A 105mm main gun, a 0.50 caliber machine gun and 1, or 2, 7.62 millimeter coaxial machine guns provide firepower required to successfully engage threats ranging from dismounted personnel, to other armored vehicles, and fixed emplacements. The tank's engine, track, and suspension systems provide the mobility, agility and maneuverability required to move rapidly through the battlefield and to take advantage of available cover and concealment. The sighting, ranging, and fire control systems provide for the detection, acquisition and accurate engagement of threats during daylight and night. The tank's armor protects it and its crew from many of the threats to its operation. Radio and intercom systems permit the crew to operate as an integrated unit, and to operate in concert with other tactical elements on, around and over the battlefield.

The crew of the M60A3 performs six major functions in employing the tank in its assigned missions. These include surveillance, movement, target engagement, maintenance, and communication as well as the tasks required to sustain the tank in operational readiness. The efficiency with which these functions are performed depends on the crew's level of proficiency in a number of individual skills and, equally important, is the level at which these individual skills have been integrated through practice. Each member of the crew must be proficient in the tasks which are unique to his position, but must also be proficient in anticipating the performance of each other member of the crew in a wide variety of operating situations, and in performing his own part of each crew function accurately, and at the proper time.

a) Surveillance. Each member of the crew is responsible for maintaining visual surveillance of a specific area. This

area of responsibility varies with circumstances, but each crew member searches for threats, signs of threat activity, and where possible, maintains visual contact with other friendly elements. In a defensive position, search areas tend to be fixed. The crew attempts to search at the greatest possible range using optical instruments and binoculars to maximize detection ranges, at the same time maintaining close-in surveillance to protect the tank from infiltration and ambush. During movement, changes in the tank's position and attitude dictate changes in the areas to be searched and in search techniques. Each member of the crew identifies terrain areas which are more likely to conceal threats and permit the movement of threat elements. In addition, the loader and the tank commander use their elevated positions in the turret to assist the driver in moving over and among obstacles and in using terrain features for cover and concealment.

Much of the crew's surveillance activity is oriented toward sensing and interpreting signs of activity on the battlefield. Since each element, whether friendly or hostile, tends to conceal itself to the maximum extent possible, crews require a high degree of skill in anticipating those areas where threats could or might be, and in interpreting fleeting indications such as dust, smoke, flash and glint, and the movement of vehicles, other tactical elements, and vegetation. The use of magnified optics in the gunner's periscope and in the tank commander's sighting and ranging equipment can be used to determine the sources of these fleeting signs, but the tank commander's binoculars tend to be used heavily because of their flexibility in covering large areas quickly, particularly during the movement of the tank.

Once threats, or distinct signs of threat activity are detected, the crewmember making the observation alerts the rest of the crew and the tank commander decides whether to engage or evade the threat, issuing appropriate commands to the driver, the gunner and the loader. Skilled crews tend to anticipate these commands and prepare to act on them, within the limits of their ability. At the same time, each crewmember continues to search his area of responsibility while responding to the immediate situation as defined by the tank commander; alerting the rest of the crew to further threats, threat indications and other events that may impact security on mission success.

b) Movement. During movement, the operation of the tank, its systems and its crew is a result of a number of compromises among mobility, firepower, armor protection and general versatility. A primary function of the tank is to move, using its mobility to find, engage and destroy

threats to the overall mission which is, in the final analysis, to take and hold ground. The tank moves to the ground to be held in such a way as to avoid the fields of fire of threats and potential threats to its movement, and places itself in advantageous firing positions with respect to its targets and areas likely to contain threats.

Movement of the tank is the responsibility of the tank commander. He identifies the objective and, where time and the situation permit, the route to the objective. The driver is responsible for the mechanics of tank movement, under the direction of the tank commander, although both driver and the tank commander really share responsibility for the selection of the fastest, most secure route. However, since the tank commander is also responsible for the overall tank security, for coordinating with other elements, and for initiating threat engagements, the time and attention he can devote to movement is limited. The skilled driver selects and negotiates the most practical route in a manner that maintains security and optimizes the position of the tank in the event of an engagement.

The loader and the gunner also play a part in the movement of the tank. When the loader is able to ride with his head out of the hatch, his position above the driver gives him a better view of the terrain between the tank and the objective. While the tank commander searches at long range with his binoculars, the loader reports obstacles, potential fields of fire and features which could be used as concealment or cover for the tank. He also reports signs of close-in threat activity. Since the gunner's field of view is limited, his ability to support rapid and secure movement of the tank depends on his skill in using his periscope to examine potential threat areas, signs of threat activity and the terrain and obstacles along the route to the objective.

Examination of the terrain between the tank and the objective, the exchange of information among the tank commander and the gunner and the information obtained in premission briefings provide the driver with a perspective of the situation which helps him to anticipate events which require specific movements of the tank for threat engagement, threat evasion or route negotiation. The ability of the driver to anticipate movement requirements reduces the tank's exposure, optimizes its speed of movement, tends to enhance its stability for firing, and maximizes its rate of fire during engagements. It also reduces demands on the attention of the tank commander and tends to minimize the time to fire the first round and to increase the accuracy of firing. The degree to which the driver can anticipate events is largely a

matter of practice, but it is also a matter of the way in which a particular crew learns to operate with the direction of a particular tank commander.

c) Target Engagement. The M60A3 is equipped with a variety of primary and secondary systems for detection, acquisition, and engagement of targets in maximum and limited visibility. The entire crew is responsible for the detection of targets and indications of threat activity, but in most cases, the tank commander is responsible for initiating and sustaining engagements. Engagements are normally initiated by a standardized fire command issued by the tank commander. The fire command contains all of the information needed by the rest of the crew to optimize the engagement. The target is identified and located for the gunner, ammunition is designated for the loader, and direction provided to the driver concerning the position and movement of the tank required before, during and after the engagement. Speed of target acquisition and engagement and first-round accuracy are of prime importance in each target engagement. The individual skills of the driver in moving into and out of the required firing position, the skill of the loader in selecting, loading, and (perhaps) unloading and clearing the main gun and coaxial machine gun, the gunner's ability to acquire and identify the target and to make proper fire control settings, and the tank commander's skill in crew direction, target designation and ranging all contribute to the effectiveness of the engagement and the security of the tank. The ability of each member of the crew to anticipate and prepare for each event significantly reduces engagement time and increases the overall effectiveness of the tank.

d) Maintenance. The tank crew is also responsible for performing much of the maintenance on the tank and its systems. The crew's primary maintenance responsibility is in performing preoperational checks and recognizing, reporting, and, where necessary, operating with system malfunctions. It is especially important that the crew recognize malfunctions in the weapon and fire control systems. During an engagement, they must be able to recognize failures quickly and employ corrective actions and/or backup modes as accurately as possible. The success of an engagement, and of the tank, depends heavily on the ability of the crew to operate with less-than-perfect systems, frequently under adverse and stressful circumstances.

e) Communication. The tank commander maintains radio and visual communication with adjacent and supporting elements and employs his tank for optimum mutual support. He also communicates with the crew, largely by means of the intercom system, providing both specific commands

and background information to support close coordination in each mission phase. Noise, stress, workload, time pressures and changing individual responsibilities demand that each message be clear, precise and brief. Standardized words, phrases and message formats are used within and among tactical elements to minimize problems in the interpretation of and response to commands and messages.

Each member of the crew uses the intercom to report significant events, including information about threats, threat indications, terrain, obstacles, friendly elements and weapon effects. Skilled crews make minimum use of the intercom, partly by making messages as brief as possible and partly by anticipating the actions and information needs of the rest of the crew to the maximum extent possible. Untrained crews make more use of the intercom than do trained crews. Skilled crews learn to integrate what is known, seen, and heard, and to act appropriately before formal commands are issued. This is especially true of the driver, who, in a specific tactical situation, knows when a threat is to be engaged, whether he will be required to stop, where to stop, or whether he should continue moving.

f) Readiness. A major part of the crew's responsibility is in maintaining the tank in readiness for action. In addition to performing regular maintenance checks, the crew must ensure that ammunition and supplies required for combat operations are stowed according to unit operating procedures. Ammunition is stowed in reserve and ready racks according to its anticipated use, with main gun ammunition stowed according to the types of targets expected to be engaged. Part of the checks involve checking for the presence, condition,and location of all relevant ammunition and supplies. In addition, the crew must be prepared to compensate for the failure of various tank, weapon,and fire control systems. Tracking systems for ranging and target engagement must be able to be used with as little degradation in timing and accuracy as possible, requiring extensive training in degraded mode operations.

Figure 4-1 serves to illustrate the complexity of M60A3 mission tasks, the interactive influence on the crew, and the courses of action available to each crew member in performing the duties required by the mission.

4.4.1 Tank Commander Tasks. The tank commander is responsible for controlling and coordinating the performance of the entire crew, and maintaining contact with adjacent and supporting friendly elements. The tank commander also has a number of individual systems which he must operate including his rotating cupola, a thermal (IR) sight, a periscope, a .50 caliber machine gun and a laser rangefinder. The tank commander also operates the radio and intercom systems.

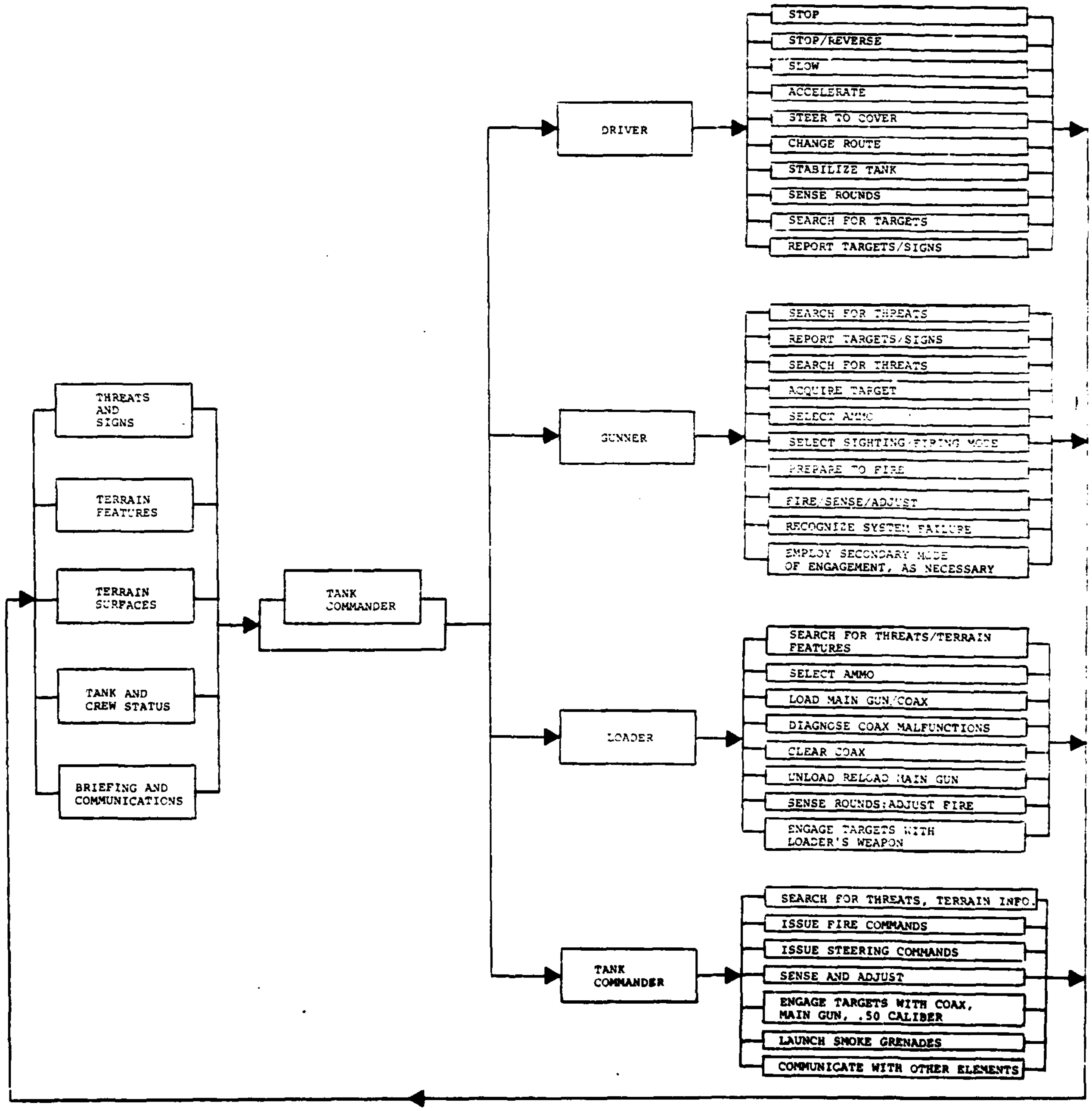


Figure 4-1 M60A3 Interactive Crew Tasks and Courses of Action

The tank commander's most important individual responsibility is in detecting threats in time to evade or engage and destroy them before his own tank is engaged. The tank commander operates with his head and shoulders out of his tank as much as possible. This position permits him to search his entire area quickly with unaided vision or with his 7-power binoculars. The tank commander's method of search varies with circumstances. When threats are expected in the area, and the terrain and the weather permit long-range visibility, the commander will tend to use his binoculars for searching; when visibility is limited by the configuration of the terrain or by weather, he may concentrate on searching with unaided vision. In areas where threats may be concealed in vegetation, smoke or fog, he may drop down into the cupola, using the thermal sight to search for thermal signatures indicating the presence of heat emitting threats.

The tank commander's .50 caliber machine gun is the tank's primary defense against aircraft. It is effective against slow-flying helicopters, but is not significant as a defense against high-performance attack aircraft. Its main purpose is in engaging personnel targets at intermediate range, and lightly armored targets. It is also effective in suppressing fire from crew served weapons and anti-tank guided missile systems, within its effective range. The .50 caliber weapon can also be used as a secondary ranging system, since its tracer burns out at known ranges, the range depending on the type of round fired.

The tank commander's most important responsibility is integrating the skills of the four-man crew to move and operate the tank, as a coordinated unit. The tank commander is, typically, an experienced crew member who has served in one or more crew positions, and has been promoted for his experience and leadership ability. He is responsible for the maintenance and operation of his tank, and for the performance of the crew as a tactical team. He is also responsible for coordinating with friendly elemen in his platoon and company, and, to a degree, with other friendly elements supporting his tank, or to which his tank must provide support. The tank commander directs his crew, and is directed in turn by his platoon leader, who is also a tank commander. The tank commander who is also a platoon leader must direct more of his attention to inter-element coordination by way of the radio and by visual means of communication, than to directing his own crew.

The tank commander is responsible for the tactical deployment of the tank, and for operation and maintenance of the tank and its systems. Specifically, he has four major functions, each of which ultimately involves the other crew members.

4.4.1.1 Terrain Evaluation. The tank commander's position in the cupola, and responsibilities to the crew and platoon, require him to obtain, evaluate, and act on as much information about

the terrain as possible. Tanks in the defense are attacked by forces moving over the terrain, using it for mobility, cover, concealment and fields of fire. Armed helicopters and scouts also use the terrain to attack or to locate the tank, and each element uses the terrain to its own best advantage. The commander of a tank, in a defensive position, at an assault line, or in an attack,interprets what he sees and knows of the terrain to predict the presence of threats, or of the cover, concealment and paths of movement available to any threat he may expect to encounter. He recognizes terrain surfaces and features which can channel his own movement or the movement of the threat, so that when minimal signs of threat activity become known, he can respond effectively.

Knowledge of, and about the terrain allows the commander (and to a degree, the rest of the crew) to predict likely threat locations, and to select the most secure and effective routes for movement toward the objective. The driver and the tank commander cooperate in route selection and negotiation, by evaluating the ability of terrain, cultural and vegetative features to support, retard, cover or conceal the movement of the tank. The driver's proximity to the terrain immediately in front of the tank enables him to evaluate and negotiate surfaces and obstacles, while the tank commander's elevated position in the turret and, usually, his more extensive tactical training and experience enable him to evaluate surfaces, features and obstacles at greater distances, and in closer to the objective. He is also in a better position to estimate and interpret the significance of signs of target activity as they influence the selection of the route and of potential positions for effective threat engagement and/or concealment.

As he searches the terrain around the tank, the commander searches for obstacles to its movement and to the movement of the threat he expects to be in the area. He also looks for places where threats might be concealed, by noting potential hiding places and cleared areas affording unobstructed fields of fire to threats which could be surveying his route from those positions. He also looks for natural channels for his own movement, to identify areas which might be mined, which might be marked for prepared artillery fire, or which might be sites for ambush by direct-fire weapons,as he identifies relevant features. He also looks for cues to surface consistency to assist the driver in picking the route affording the best combination of cover, speed, and firing position for an existing situation, or for one that is anticipated.

Another aspect of terrain evaluation is relating terrain features and characteristics to what is known of the deployment of other friendly elements. An area in which the tank would ordinarily be vulnerable could be used as a route or as a firing position, if it and the fields of fire into it are known to be covered by supporting air or ground elements.

4.4.1.2 Target Detection and Recognition. Targets are detected and engaged by the M60A3, to eliminate threats to its own movement to the objective and to the presence and movement of other friendly elements. Most targets are sited and moved to minimize their vulnerability and to maximize their advantage in evading, neutralizing, or destroying friendly elements. Maximum use is made of camouflage, cover, concealment, and suppressive and supporting fires, making most targets for the M60A3 difficult to find, fix and engage. The tank commander is responsible for maintaining surveillance to maximize the range at which targets are detected, identified and evaluated. Unless the tank is in contact with hostile elements, the tank commander searches the area with unaided vision and with his binoculars, riding with his head and shoulders out of the cupola hatch. In addition, he assigns a sector of responsibility to the loader, who also operates out of his hatch to the maximum extent possible.

When the tank is engaged, or when it is about to come into contact with the enemy, and during friendly artillery preparatory fire, the tank commander must maintain surveillance with a "popped hatch", whereby his field of view is limited by the overhead protection of the hatch cover. The commander relies heavily on adjacent and supporting elements for surveillance and target detection but ultimately, it is he who must acquire the threat so that it can be assigned as a target, avoided or assigned a priority for further action. During "popped-hatch" operations, in close engagements or in NBC operations, when visibility is severely limited by masks as well as by the fields of view available in periscopes and vision blocks, the tank commander is at a distinct disadvantage in target detection.

Target recognition is the result of a number of kinds of perceptual information, including the shape and configuration of the target, its behavior and location, and information about what is expected in the area surveyed. In a fluid battlefield, it is difficult for crews to distinguish among friendly and hostile elements except through the recognition of the distinguishing shapes of the elements. In less fluid situations, elements to the front can frequently be considered hostile, and those to the rear, friendly. Airborne elements are especially difficult to recognize because of their mobility, and require that the crew have good, current intelligence and good communication with other friendly units.

Frequently, targets are detected initially as the crew senses smoke, dust, glint, flash, movement or other indications of possible threat activity. When such signs are detected, the commander searches the area with binoculars (if he is out of the hatch) or with his thermal or optical sights, using the IR signature and/or optical magnification to examine the area in more detail. Threats to the M60A3 are difficult to identify at ranges beyond 1000 meters in good visibility without powered instruments, but those ranges are significantly increased when seven or eight-power instruments are available.

4.4.1.3 Tactical Decision Making. The tank commander is the tactician of the crew, and perhaps of the section or the platoon. He makes decisions concerning the method by which the tank will be employed in its assigned mission, weighing vulnerability, speed, maneuverability, firepower, support, terrain, and threat factors in selecting and implementing courses of action. The tank commander decides which route to take to the objective, which threats to engage and in which order, the method of engagement to be used, the firing mode or position from which to fire, and the way in which the tank will operate relative to other tanks in the element and platoon. He also decides when to request the support of other elements and how to maximize his tank's effectiveness with or without that support.

Tactical decision making involves current information, available through direct or powered viewing and through the interpretation of radio messages and other means of communication. It also involves weighing these indications about the present situation with information obtained in premission briefings, map study, and, where possible, prior experience with the terrain, the enemy and with other friendly elements.

At each point in the tank mission, the tank commander must evaluate the available information as it relates to his mission, his tank, his crew and their capabilities and limitations. Once targets are detected, they must be evaluated in terms of type, range, lethality and expected effect on the mission. Decisions must be made to engage or evade targets, or to seek further information about them. Where multiple targets are presented, they must be assigned priority for engagement or evasion depending on their immediate potential as threats to the mission. Tank commander decisions are the primary influence on the rest of the crew, since these determine where the driver will drive, when and what the gunner will fire, and how the loader will perform to assure the availability of the right ammunition at the right time.

4.4.1.4 Target Engagement. The M60A3 is designed to permit target engagement by the gunner under direction of the tank commander, so that the tank commander can maintain surveillance of the battle area, and continue to guide the driver in the negotiation of routes and firing positions. The M60A3 also permits the tank commander to engage targets simultaneously with the gunner, using his .50 caliber machine gun. When the gunner is incapacitated, or when suppressive machine gun fire is required in the target area during a main gun engagement, the tank commander may also fire the main gun or coax machine gun from his position. In most instances, the tank commander supports main gun engagements by providing gross lays in the target area (for gunner target acquisition) and by providing range inputs by way of the laser rangefinder, or secondary means.

The tank commander may also engage targets with his .50 caliber machine gun, either to provide suppressive fire, reconnaissance-by-fire, or simultaneous engagement of targets out of the zone of fire of the main or coax guns. During these periods, the driver and the gunner, to the extent possible, must provide the surveillance required to maintain local security and to detect threats in the battle area.

Engagements are controlled by the tank commander by means of standardized fire commands. Each element of the fire command is set in a fixed relationship to each other element, with words chosen for brevity and intelligibility under conditions of stress and noise. Each member of the crew receives information in the fire command, needed to coordinate his responsibilities with those of other crew members. While each tank commander optimizes his crew's performance by means of individual techniques, the standardization of the fire command assures that no member of the crew will require more than a bare minimum of interpretation in obtaining the information he needs to perform his job rapidly and accurately.

4.4.1.5 Communications. The tank commander communicates with the crew over the intercom, and with adjacent and supporting elements by means of radio and visual signals. Radio transmissions are usually kept to a minimum for security reasons, with most interactions among elements established by standard operating procedure, or visual signals. Communications among commanders are also minimal, especially when the crews are well trained and carefully briefed.

The tank commander's job is complex, and requires extensive training and experience. Following is a list of specific tasks in which the M60A3 tank commander must be proficient.

1) <u>SURVEILLANCE AND TARGET ACQUISITION</u>

- o Perform ground and aerial surveillance in assigned sector of search
- o Acquire ground targets (day/night)
- o Acquire aircraft targets (day/night)

2) <u>ASSISTS IN FIRING ENGAGEMENTS</u>

- o Selects firing positions (day/night)
- o Issues fire commands
- o Assists gunner when firing main gun engagements
- o Assists gunner when firing coaxial machine gun engagements

- o Assists gunner when firing rangecard engagements

- o Assists loader when firing loader's weapon system

3) <u>MAIN GUN FIRING ENGAGEMENTS</u>

- o Fires main gun battlesight engagements

  Using the rangefinder (stationary target/stationary tank)

- o Fires main gun battlesight engagements

  Using the rangefinder (stationary target/moving tank)

- o Fires main gun battlesight engagements

  Using the rangefinder (moving target/moving tank)

- o Fires main gun battlesight engagements

  Using the commander's thermal sight (stationary target/ stationary tank)

- o Fires main gun battlesight engagements

  Using the commander's thermal sight (stationary target/ moving tank)

- o Fires main gun battlesight engagements

  Using the commander's thermal sight (moving target/ moving tank)

- o Fires main gun precision engagements

  Using the rangefinder (stationary target/stationary tank)

- o Fires main gun precision engagements

  Using the rangefinder (stationary target/moving tank)

- o Fires main gun precision engagements

  Using the rangefinder (moving target/moving tank)

- o Fires main gun precision engagements

  Using thermal sight (stationary target/stationary tank)

- o Fires main gun precision engagements

  Using the commander's thermal sight (stationary target/ moving tank)

- o Fires main gun precision engagements

  Using the commander's thermal sight (moving target/ moving tank)

4) <u>FIRING ENGAGEMENTS UNDER CONDITIONS OF LIMITED VISIBILITY</u>

- o Prepares a sketch rangecard
- o Prepares a circular rangecard
- o Assists gunner when gunner fires main gun rangecard lay to direct fire
- o Assists gunner when gunner fires coax rangecard lay to direct fire
- o Assists loader when loader fires his weapon during conditions of limited visibility
- o Fires main gun rangecard lay to direct fire using the rangefinder (stationary target/stationary tank)
- o Fires main gun rangecard lay to direct fire using the rangefinder (moving target/stationary tank)
- o Fires main gun rangecard lay to direct fire using the commander's thermal sight (stationary target/stationary tank)
- o Fires main gun rangecard lay to direct fire using the commander's thermal sight (stationary target/moving tank)
- o Fires coax rangecard lay to direct fire using rangefinder (stationary target/stationary tank)
- o Fires coax rangecard lay to direct fire using commander's thermal sight (stationary target/stationary tank)
- o Fires coax rangecard lay to direct fire using commander's thermal sight (stationary target/moving tank)
- o Fires caliber .50 rangecard lay to direct fire (stationary target/stationary tank)
- o Fires caliber .50 rangecard lay to direct fire (stationary target/moving tank)
- o Fires night engagements with artificial illumination

5) TANK COMMANDERS COAXIAL WEAPONS SYSTEM FIRING ENGAGEMENTS

- o Fires coax battlesight engagements using the rangefinder (stationary target/stationary tank)
- o Fires coax battlesight engagements using the rangefinder (stationary target/moving tank)
- o Fires coax battlesight engagements using the rangefinder (moving target/moving tank)
- o Tank commander fires coax battlesight engagements using the commander's thermal sight (moving target/moving tank)
- o Tank commander fires coax precision engagements using the rangefinder (stationary target/stationary tank)
- o Tank commander fires coax precision engagements using the rangefinder (stationary target/moving tank)
- o Tank commander fires coax precision engagements using the rangefinder (moving target/moving tank)
- o Tank commander fires coax precision engagements using the commander's thermal sight (stationary target/stationary tank)
- o Tank commander fires coax precision engagements using the commander's thermal sight (stationary target/moving tank)
- o Tank commander fires coax precision engagements using the commander's thermal sight (moving target/moving tank)
- o Fires coax battlesight engagements using the commander's thermal sight (stationary target/stationary tank)
- o Fires coax battlesight engagements using the commander's thermal sight (stationary target/moving tank)

6) TANK COMMANDER WEAPON SYSTEM ENGAGEMENTS

- o Fires caliber .50 ground battlesight engagements (stationary target/stationary tank)
- o Fires caliber .50 ground battlesight engagements (stationary target/moving tank)
- o Fires caliber .50 ground battlesight engagements (moving target/moving tank)

- Fires caliber .50 air engagements at low performance aircraft (moving stationary tank)

- Fires caliber .50 air engagements at high performance aircraft (moving, stationary tank)

7) EMPLOYMENT OF THE MACHINE GUN SYSTEMS

- Uses the tank machine guns under special conditions (ranging, designated targets, firing through cover, incendiary effects, and ricochet fire)

- Re-engages targets

- Performs reconnaissance by fire

- Uses suppressive fire techniques

- Initiates fire commands

- Issues subsequent fire commands

- Engages area targets with commander's weapon using the "Z" pattern

- Uses range estimate techniques (tracer burnout)

8) SMOKE GRENADE LAUNCHERS

- Activates smoke grenade launchers

- Operates grenade launchers

MISCELLANEOUS TASKS

1) BORESIGHTING THE TANK

- Prepare tank for boresighting

- Coordinates crew efforts in boresighting of the tank

2) ZEROING THE TANK

- Zero tank main gun

- Zero .50 caliber MG

- Zero coaxial weapon system

- Zero loader's weapon

3) <u>LASER RANGEFINDER</u>

- o Install safety filter on receiver/transmitter unit
- o Perform LRF self-test
- o Boresight LRF sight
- o Perform target range input (laser)
- o Perform target range input (manual)
- o Place rangefinder into operation and range accurately
- o Perform rangefinder checks

4) <u>COMMANDER'S PERISCOPE M36E1</u>

- o Conduct before-operations maintenance checks and services on periscope M36E1
- o Install M36E1 periscope image intensifier elbow, visible light elbow, and body assembly
- o Remove M36E1 periscope image intensifier elbow, visible light elbow, and body assembly
- o Conduct after-operations maintenance checks and services on periscope M36E1

5) <u>TANK THERMAL SIGHT (TTS)</u>

- o Inspect tank thermal sight
- o Prepare TTS for operation
- o Perform TTS system test

6) <u>TURRET POWER OPERATION</u>

- o Operation of gun elevating and turret traversing system in stabilized and non-stabilized mode
- o Place turret into power operation

7) <u>AUXILIARY EQUIPMENT</u>

- o Perform night binocular checks
- o Use hand-held night vision devices

8) NBC EQUIPMENT

- o Performs gas particulate check
- o Performs all crew duties while wearing NBC protective equipment and clothing

9) LAND NAVIGATION SYSTEM

- o Places land navigation system into operation
- o Performs land navigation using the reference heading
- o Readout information

10) COMMUNICATIONS

- o Operate tank radio
- o Perform operational checks on tank radios
- o Uses correct radiotelephone procedures

4.4.2 Loader Tasks. The loader's primary task is to load the main tank gun. He is also responsible for loading and maintaining the coaxial machine gun and for surveillance of the battle area, when he can be spared from his primary responsibilities.

In some respects, the loader's job is the most demanding, especially in the M60A3 as it fires on the move, in the stabilized mode. The loader must select the correct ammunition from the ready-rack, loading it into the breech of the main gun as it moves in elevation with respect to the turret floor. Even in stationary engagements, the loader must be careful to avoid finger contact with the breechblock. He must also avoid being struck by the breech as it recoils; he must avoid the hot, empty shell casing as it is automatically ejected and dropped to the turret floor. When more than one round is fired in an engagement, the loader must be able to maximize the rate of fire so as to destroy or neutralize the target before it can return fire. At the same time, he must maintain his balance in a moving environment, with an accumulation of shell casings on the floor of the turret.

When firing the coaxial machinegun, the loader must keep track of the rate at which ammunition is expended, so that he can reload the ammunition box before it is empty. Ordinarily the gunner reloads the machine gun ammunition between engagements, but he must be proficient enough to do it rapidly, and on the move if necessary.

The loader is also responsible for detecting, diagnosing and clearing malfunctions in the main gun and the coaxial machinegun.

Malfunction procedures with the main gun are relatively fixed and straightforward, but coax failures can be more complicated. A coax stoppage may be the result of a bad round, a dirty or bent round, an electrical malfunction, or a change in headspace due to wear. The loader must recognize, primarily by means of aural cues, what produces the stoppage so that he can employ immediate remedial action.

Between engagements, and when an engagement is not imminent, the loader searches an assigned area to ensure local security and to detect threats as far away as possible. Ordinarily, the loader does not use the tank's binoculars, but he may occasionally share them with the tank commander. For combat, and in combat-ready units, loaders tend to acquire binoculars not in the normal TO&E. In certain terrain, of course, binoculars are of little advantage, but in the central European environment, they are essential in searching areas within the crew's field of view, since threats could be located within view at well beyond 3000 meters. During closed-hatch operations, when the tank is receiving fire, or in an NBC environment, the loader maintains surveillance using his unity-power vision block, which he mounts in his hatch cover. The vision block provides a severely limited field of view, but can be useful in surveying the loader's sector of responsibility.

The M60A3 may be equipped with a 7.62mm machine gun to be used by the loader. When the loader is not involved in main gun loading, the 7.62 is particularly effective against hostile troops equipped with ATGM's when hard targets are not being engaged. When fired with other 7.62's and .50 caliber guns from supporting elements, the 7.62 can be effective against slow-flying aircraft and helicopters by disrupting the aircraft's ability to bring accurate fire against the tank(s).

The loader's tasks include the following:

SURVEILLANCE

- Maintain surveillance of the loader's search sector, using unaided vision or loader's periscope
- Report threats and signs of possible threat activity to the tank commander
- Provide guidance in obstacle clearance to driver

COMMUNICATIONS

- Prepare tank radio for operation
- Operate vehicular intercommunications equipment
- Prepare combat vehicle crewman's helmet (CVC) for operation

- Perform operator maintenance on radios and accessories

MAIN GUN WEAPON SYSTEM

- Load 105mm round
- Unload 105mm round
- Perform Emergency Closing of Main Gun Breech
- Service and Check Main Gun Ammunition
- Store Main Rounds in the Tank
- Set Range Fuse Settings on Beehive Ammunition
- Determine Corrective Action Required by Replenisher Tape
- Load Ammunition (Load a Basic Load Using a Unit Load Plan)
- Disassemble the Breech Block
- Remove the Main Gun Breech Block Group
- Assemble Breech Block
- Adjust Variable Breech Operating Cam
- Perform Emergency Closing of Main Gun Breech
- Clean and Lubricate the Breech Block, Cannon Bore and Bore Evacuator of the Tank after Operations
- Perform Main Gun Prepare-to-Fire Procedures from the Loader's Position
- Identify Main Gun Ammunition
- Remove Main Gun Rounds from Ready Rack
- Load Main Gun Rounds into Ready Rack
- Loads Main Gun Rounds into Tubular Ammunition Racks (Bustle)
- Extract a Fired 105mm Cartridge Case
- Perform Failure to Load Procedures
- Perform Failure to Extract Procedures
- Unloads Main Gun Rounds from Tubular Ammunition Racks (Bustle)

- Perform Failure to Fire Procedures (Misfire)
- Operate Turret Ventilator Blower System
- Place Main Gun Safety Switch in Safe Position
- Select and Load the Announced Ammunition Under Low Ambient Light Conditions
- Perform Tactical Safe-to-Fire Procedures During Main Gun Engagements
- Perform Tactical Safe-to-Fire Procedures During Coaxial Weapon Engagement
- Removes Expended 105mm Cartridge Cases From the Turret

LOADER'S WEAPON SYSTEM

- Stow Weapon System
- Unstow Weapon System
- Prepare Weapon System for Operation
- Fire Weapon System
- Disassemble and Assemble Loader's Weapon System
- Inspect and Maintain Loader's Weapon System
- Check Operation of Loader's Weapon System
- Mount Loader's Weapon System in Tank
- Remove Loader's Weapon System from Tank
- Boresight Loader's Weapon System
- Load and Unload Loader's Weapon System
- Clear Loader's Weapon System
- Troubleshoot Loader's Weapon System Using Table 3-6, DEP 9-2350-253-10

COAXIAL WEAPON SYSTEM

- Disassemble and Assemble MAG-58 MG
- Inspect and Maintain MAG-58 MG
- Check Operation of MAG-58 MG

AD-A091 422 SINGER CO BINGHAMTON NY LINK DIV F/G 19/3
DESIGN DEFINITION STUDY REPORT. FULL CREW INTERACTION SIMULATOR--ETC
JUN 78 N61339-77-C-0185
UNCLASSIFIED LR-895-VOL-1 NAVTRAEQUIPC-77-C-0185-000 NL

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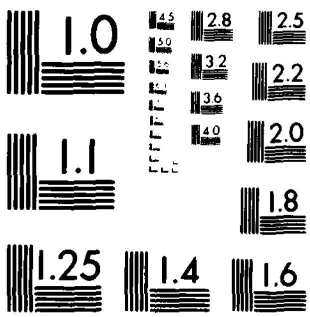

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

- o Mount MAG-58 MG in a Tank
- o Remove MAG-58 MG from a Tank
- o Boresight MAG-58 MG
- o Load MAG-58 MG
- o Unload and Clear MAG-58 MG
- o Troubleshoot MAG-58 MG Using Table 3-6, DEP 9-2350-253-10
- o Service and Check Coaxial MG Ammunition
- o Stow MG Ammunition
- o Remove Expended Cartridge Cases from the Turret

MISCELLANEOUS

- o Prepare Tank for Boresighting
- o Load and Unload Smoke Grenade Launcher
- o Perform Smoke Grenade Launcher Misfire Procedures
- o Install and Remove M37 Periscope
- o Operate Stabilization Emergency Shut-Off Switch
- o Perform Loader Checks Prior to Placing Turret in Power Operation

4.4.3 Gunner Tasks. The gunner in the M60A3 is responsible for the accuracy with which the main gun is fired. The rest of the crew assists the gunner by positioning the tank (driver), providing a functioning loaded gun (loader), and by laying the gunner's sights in the immediate vicinity of the target for rapid target acquisition in the gunner's sights (tank commander). After the gun is fired,all crew members observe the effect of the round, to provide the gunner with information to adjust his fire for further effect, or prepare for the acquisition of another target.

The gunner's job is to make the necessary settings in the ballistic computer to apply appropriate sight elevation to the gun, to acquire the target in his sight as quickly as possible, to track the target if it moves, and to adjust fire in case of a miss or when the first round does not have the required effect. When the primary sighting system is not available due to malfunction or damage, the gunner must use the telescope, using alternate ranging techniques as supplied by the tank commander, or by the gunner himself.

When firing on moving targets, the gunner applies lead, using the lead lines on his aiming reticle or by using the lead-computing function of the fire control system.

The gunner's magnified optics and his position in the turret give him an advantage over the loader and the driver in target detection, especially at long ranges. His limited field of view almost requires that some other crew member guide him when searching the terrain through his periscope. Between engagements or during maneuvers to contact, the gunner slews the turret to provide coverage of his search sector at intermediate to long ranges (1500-3000 m or more) depending on the terrain.

During maneuvers, the gunner employs his magnified optics to assist the driver by examining the terrain to determine surface bearing capabilities. He (the gunner) also examines obstacles which are too far away, or out of the driver's field of view. The tank commander may also perform these tasks, although he normally concentrates on long-range search for threat indications.

The gunner's performance in discriminating targets is facilitated by guidance from the tank commander, who lays the gun to place the target in his field of view, describes the target and, when necessary, identifies it for the gunner by some prominent feature in the area. When the tank commander's workload is too high to permit this level of communication, the gunner makes the necessary discriminations on his own initiative.

A major problem lies in the preparation of range cards for indirect fire and for direct fire during periods of limited visibility. Range card firing requires that the gunner sight on likely target areas from a fixed position, using a fixed referance near the tank as an aiming point. The range card is prepared on a circular grid, or as a sketch of the terrain in which azimuths and elevations are noted, between the aiming point and features within the target area.

Range cards are passed from one tank to another, as the relief tank is moved into position with respect to the aiming point. Typically, gunners have difficulty in visualizing azimuth relationships within the target area, the aiming stake, the gun and the azimuth indicator.

When direct firing from a range card, the crew observes the target area to determine weapon effects. At night, if illumination from flares or searchlights is available, the gunner adjusts his sight into the target. Where illumination is not available, he and the other crew members use the illumination provided by the round fired in adjusting subsequent rounds.

The gunner operates in both unlimited and limited visibility, using optical and thermal sighting equipment. Even in daylight, or with good nighttime illumination, he may use thermal and optical sights together, using the IR signature to locate concealed targets. Weapon effects and battlefield illuminants make it difficult for the gunner to maintain his night vision capability, but where illumination is minimal, the gunner preserves his night vision sensitivity by closing his eyes as he fires, opening them in time to sense weapon effect for the adjustment of subsequent rounds. The basic tasks required of the gunner are as follows:

TARGET ACQUISITION

- Recognize Target Indications, Shape, Color and/or Landmarks Defining Target Location as indicated by Tank Commander

AMMUNITION SELECTION

- Selects Ammunition for Specific Target Types and Indexes Ammunition in Ballistic Computer

MAIN GUN FIRING ENGAGEMENTS

- Fires Battlesight Engagements Using the Gunner's Periscope (Stationary Target/Stationary Tank)
- Fires Battlesight Engagements Using the Gunner's Periscope (Stationary Target/Moving Tank)
- Fires Battlesight Engagements Using the Gunner's Periscope (Moving Target/Moving Tank)
- Fires Battlesight Engagements Using the Gunner's Thermal Sight (Stationary Target/Stationary Tank)
- Fires Battlesight Engagements Using the Gunner's Thermal Sight (Stationary Target/Moving Tank)
- Fires Battlesight Engagements Using the Gunner's Thermal Sight (Moving Target/Moving Tank)
- Fires Battlesight Engagements Using the Gunner's Telescope (Stationary Target/Stationary Tank)
- Fires Battlesight Engagements Using the Gunner's Telescope (Stationary Target/Moving Tank)
- Fires Battlesight Engagements Using the Gunner's Telescope (Moving Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Periscope (Stationary Target/Stationary Tank)

- Fires Precision Engagements Using the Gunner's Periscope (Stationary Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Periscope (Moving Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Thermal Sight (Stationary Target/Stationary Tank)
- Fires Precision Engagements Using the Gunner's Thermal Sight (Stationary Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Thermal Sight (Moving Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Telescope (Stationary Target/Stationary Tank)
- Fires Precision Engagements Using the Gunner's Telescope (Stationary Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Telescope (Moving Target/Moving Tank)
- Apply Immediate Action in case of Main Gun Failure to Fire
- Uses Gunner's Standard Adjustment Technique
- Set Tank Battlesights
- Employ Misfire Procedures
- Uses Target Form Technique
- Employs MIL Change Technique
- Employs Range Change Technique
- Applies Relay Technique
- Identify A Proper Sight Picture and use all Sight Reticles
- Employs Burst On Target Method of Fire Adjustment
- Performs Fire Adjustments Based on TC's Subsequent Fire Commands
- Perform Prepare-To-Fire Checks
- Sense Rounds
- Performs Ranging Machine Gun Adjustments

- Checks Status of Replenisher Before, During and After Firing Main Gun

COAXIAL WEAPONS SYSTEM ENGAGEMENTS

- Fires Battlesight Engagements Using the Gunner's Periscope (Stationary Target/Stationary Tank)
- Fires Battlesight Engagements Using the Gunner's Periscope (Stationary Target/Moving Target
- Fires Battlesight Engagements Using the Gunner's Periscope (Moving Target/Moving Tank)
- Fires Battlesight Engagements Using the Gunner's Thermal Sight (Stationary Target/Stationary Tank)
- Fires Battlesight Engagements Using the Gunner's Thermal Sight (Stationary Target/Moving Tank)
- Fires Battlesight Engagements Using the Gunner's Thermal Sight (Moving Target/Moving Tank)
- Fires Battlesight Engagements Using the Gunner's Telescope (Stationary Target/Stationary Tank)
- Fires Battlesight Engagements Using the Gunner's Telescope (Stationary Target/Moving Tank)
- Fires Battlesight Engagements Using the Gunner's Telescope (Moving Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Thermal Sight (Stationary Target/Stationary Tank)
- Fires Precision Engagements Using the Gunner's Thermal Sight (Stationary Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Thermal Sight (Moving Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Telescope (Stationary Target/Stationary Tank)
- Fires Precision Engagements Using the Gunner's Telescope (Stationary Target/Moving Tank)
- Fires Precision Engagements Using the Gunner's Telescope (Moving Target/Moving Tank)
- Employs the "Z" Firing Pattern Against Area Targets

ASSISTS TK COMMANDER IN FIRING ENGAGEMENTS

- Assists Tank Commander when Commander Fires Main Gun Engagements
- Assists Tank Commander When Commander Fires Coaxial Weapon Engagements
- Assists Tank Commander when Commander Fires Commander's Weapon Engagements
- Assists Tank Commander when Commander Fires Rangecard Lay to direct Fire Engagements

FIRING ENGAGEMENTS UNDER CONDITIONS OF LIMITED VISIBILITY

- Prepare a Sketch Rangecard
- Prepare a circular Rangecard
- Prepare Azimuth Indicator for Operation
- Operate Azimuth Indicator
- Operate Elevation Quadrant
- Operate Gunner's Quadrant
- Gunner Fires Main Gun Rangecard Lay to Direct Fire
- Using the Gunner's Periscope (Striking/Missing Target)
- Gunner Fires Coax Rangecard Lay to Direct Fire using the Telescope (Stationary Target/Moving Target)
- Gunner Fires Main Gun Rangecard Lay to Direct Fire using the Gunner's Thermal Sight (Stationary Target/Stationary Tank)
- Gunner Fires Main Gun Rangecard Lay to Direct Fire using the Gunner's Thermal Sight (Moving Target/Stationary Tank)
- Gunner Fires Main Gun Engagements Employing Rangecard Firing Data
- Gunner Fires Coaxial Weapon Engagements Employing Rangecard Firing Data
- Employs Area to Point Firing Patterns when Firing from a Rangecard
- Prepare Tank for Firing as Artillery

- Prepare the Tank for Firing After Moving into a Prepared and Marked Firing Position

- Perform Slippage and Accuracy Check

SENSE AND ADJUST INDIRECT FIRES

- Requests Supporting Fires (Air, Artillery)

- Sense Supporting Fires

- Adjusts Supporting Fires

TURRET OPERATIONS

- Place Turret in Manual Operation

- Perform a Zero-Pressure Check (Hydraulic Power Pack)

- Place Turret into Power Operation

- Place Turret in Stabilized Operation

- Operate Gun Elevating and Turret Traversing System in Stabilized Mode

- Place Stabilizer in Standby Mode

- Position Gun Tube in Cradle in response to Signals

- Track targets smoothly

- Perform Stabilization Check

- Perform Manual Elevation Check

- Adjust and Control Gun Reticle Lights

BORESIGHTING THE TANK

- Prepare Tank for Boresighting

- Complete Boresight Procedures

ZEROING THE TANK

- Perform Main Gun Prepare-to-Fire Checks

- Zero Tank Main Gun

COAXIAL WEAPONS SYSTEM

- o Boresight MAG-58 Mounted on a Tank
- o Zero MAG-58 MG

MISCELLANEOUS

GUNNER'S TELESCOPE

- o Prepare Gunner's Telescope for Operation
- o Boresight Gunner's Telescope
- o Select Correct Ammunition Reticle

M35E1 GUNNER'S PERISCOPE

- o Perform Before-Operations Maintenance Checks and Services and Prepare M35E1 for Operation
- o Install M35E1 Periscope Image Intensifier Elbow, Visible Light Elbow and Body Assembly
- o Remove M35E1 Periscope Image Intensification Elbow, Visible Light Elbow, and Body Assembly
- o Perform After-Operation Maintenance Checks and Services on Periscope M35E1
- o Boresight M35E1 Gunner's Periscope
- o Perform Sight Purging Check (Prepare to Final Check)

LASER RANGEFINDER

- o Perform LRF Self-Test
- o Perform LRF Malfunction Detection Test
- o Perform LRF Range Test
- o Perform Target Range Input (Laser)
- o Perform Target Range Input (Manual)
- o Perform Rangefinder Checks

MUZZLE REFERENCE SYSTEM

- o Activate Muzzle Reference System
- o Manually Operate Muzzle Reference System

TANK THERMAL SIGHT

- o Install TTS*
- o Remove TTS*
- o Inspect Tank Thermal Sight
- o Prepare Tank Thermal Sight for Operation
- o Perform TTS System Test
- o Boresight TTS

XM 21 COMPUTER

- o Perform XM 21 Computer Self-Test Procedures
- o Perform XM 21 Computer Elevation Channel Check
- o Perform Computer Check
- o Perform Superelevation Check
- o Place XM 21 Computer into Operation

4.4.4 Tank Driver Tasks. The driver moves the vehicle from one place to another over a variety of terrain surfaces always conscious of the tactical environment in which he operates, and aware that he might encounter threats at any time. The novice driver takes detailed direction from the tank commander, who helps him to select the best route for speed, agility, concealment, stabilization of the turret for sighting and firing, and to coordinate movement with adjacent and supporting elements. The tank commander, based on his experience as a crewman, also provides guidance on the best way to approach obstacles and marginal terrain surfaces, and helps the driver to minimize stress on the track and suspension system. He also provides direction in the selection of positions from which to fire, where as much of the tank is concealed, or protected, as possible.

The skilled driver constantly searches the area to his front, to anticipate changes in the situation requiring changes in his performance. He also associates specific terrain surfaces and obstacles with the capabilities and limitations of the tank and with the probable effects on the tank and the performance of the rest of the crew when these surfaces and obstacles are to be negotiated. The driver also searches the area for threats and signs of threat activity. He evaluates

*Assumes TTS Not Permanently Installed

what he sees in the area between himself and the objective and its ability to conceal and impede, or support the movement of possible threats, and his own tank. A skilled driver requires minimal direction from the tank commander, anticipating the needs of the crew through his interpretation of what he sees and learns about the mission, the tactical situation, and the mission environment.

The driver's job requires extensive training and experience in moving the tank over various types of terrain, and operating the tank in the battlefield environment to maximize total crew performance within its assigned missions. The experienced driver is skilled in both the operation of the tank within its operating limits, and providing the crew with the best possible platform for target acquisition, engagement and destruction, while minimizing its vulnerability to a wide variety of battlefield threats.

During basic driving training, the driver learns to operate the tank's driving controls to start, stop and steer the tank both forward and backward. By negotiating surfaces and obstacles within the capabilities of the tank, he learns to associate the tank's performance with various conditions it could encounter on the battlefield. In the central European environment, the tank can negotiate almost any terrain it is likely to encounter, but there are obstacles and surface characteristics beyond its capacity. Even those which it can negotiate have specific effects on the tank and crew performance, and require the driver to learn to anticipate these effects.

The driver, like the rest of the crew, learns to operate in limited visibility, using unaided vision and his night driving display. He also learns to drive with the hatch closed, using his three vision blocks for driving reference. Opportunities for learning driver skills, especially in negotiating difficult terrain and obstacles, are rare. Useful terrain for driver training at the BAT level is very limited. Where opportunities do exist in unit training, they tend not to be used as heavily as they might due to resultant maintenance problems. The driver should learn how to avoid losing a track, for example, by being exposed to the sounds, vibrations, and control reactions associated with track stress. To expose him to these effects in the real world, however, is expensive and may not be justified by the proficiency it would develop.

The driver's tactical responsibilities are more stringent than those involved in simply moving the tank from place to place. The driver is ultimately responsible for how often, how long and how clearly the tank is seen from various threat positions along its route. He is responsible for providing the gunner, loader, and the tank commander with a stable platform for sighting, loading, and firing. He is responsible for detecting targets, threats and threat indications and for sensing the effects of rounds fired by the gunner and the tank commander.

Like the tank commander, the driver looks ahead as far as he can, so that he can anticipate events as much in advance as possible. He looks for covered and concealed routes to the objective and examines the terrain for surface characteristics which could impede or stop the movement of the tank, or which could impose undue stresses on the crew or on the tank itself. He also looks for terrain features, buildings, vegetation and terrain surfaces having implications for the deployment, movement and concealment of enemy elements which could threaten his own tank. As he moves the tank to the objective, he avoids obvious fields of fire, and searches each possible threat position for signs of threat presence or activity. Tanks, artillery, personnel carriers and even dismounted troops are all potential threats. Where time permits, the driver alerts the crew to any threats he detects, and responds to driving commands from the tank commander. Where time is short, the driver takes evasive action without direction, alerting the crew to the nature, location and approximate range of the threat as he moves to a covered or concealed position.

The driver also avoids areas which might be mined or which might be sighted-in for indirect artillery fire. This requires that he evaluate available visual information and tactical information available in premission briefings and during the mission, primarily over the radio net.

When engagements are expected, the driver searches for the best place to position the tank in case a fire command is issued. Ideally, he tries to place the tank in a position where only the gun and periscope windows are exposed, and where he can move quickly and unobtrusively to an alternate position for subsequent firing. When the turret is operated in the stabilized mode, the driver looks for a surface which will facilitate movement during firing, with a minimum of disturbances to the crew in the turret.

Frequently, of course, the driver does not have any good choices available to him in minimizing vulnerability and in maximizing overall effectiveness. In these situations he must evaluate the relative importance of turret stability, cover and concealment, speed, agility and waiting to sense and adjust the rounds fired. Normally the tank commander assists in these tradeoffs. Occasionally, tank commander participation is not available and the driver is required to make decisions to which the rest of the crew must adjust.

The driver has a profound effect on the performance of the entire crew. His choice of route and position can determine whether the objective and areas of possible threat deployment can be seen from the turret, and whether accurate fire can be brought against targets in the battle area. Driver performance can also significantly determine the vulnerability of the tank. If he drives or stops the tank in an exposed position, he could be engaged before the threat is apparent. If he moves the tank

through concealment, but causes movement in the trees or other vegetation, he can be readily detected and engaged. If he leaves tracks into an area of concealment, he may also become vulnerable to weapons able to penetrate that concealment. Driving the tank through terrain which will not support it, or between obstacles too close to permit passage can strongly effect the vulnerability of the tank and degrade the performance and the security of other friendly elements.

The driver's performance effects the gunner, the loader and the tank commander, and conversely the gunner, loader and tank commander influence and performance of the driver. The driver is in a position to view terrain to his immediate front, and with severe limits, the area beyond his fenders. The other members of the crew, higher up in the tank, provide information to the driver about surfaces, distances, threats and threat indications which he cannot see. While this is largely the responsibility of the tank commander, the loader and the gunner provide information when it is available, when it seems appropriate, when the tank commander is occupied with target acquisition, communications or engagements, or when his (tank commander's) view of the driver's area of responsibility is obscured. In tank operations, it is sometimes necessary for the loader to dismount to examine the terrain along the route for load-bearing capability, mines, or vulnerability from areas from which it might be obscured. Airborne or surface reconnaissance elements can also supply some of this information, or it can be supplied by adjacent elements able to view the area in question.

Although the most critical driver skills relate to tactical maneuvers around the battlefield, in the day and in periods of limited visibility, driver skill is also important in road marches, where the driver must maintain position in the formation. This is not difficult during periods of unlimited visibility, but requires a high degree of skill at night, and in fog, rain and snow. Tactical movements frequently take place during periods of poor visibility to take advantage of available concealment. As a result, driver skill in adverse conditions is not only hard to develop, but is also critical in the missions of the tank.

The driver is also responsible for crew-level maintenance of a major part of the tank and its systems. The driver's specific tasks include:

BEFORE-OPERATION MAINTENANCE CHECKS & SERVICE

- Before-Operation Maintenance Checks & Services on Tank Instruments, Gages & Warning Lights (Engine Running/ Engine Off)

- Before-Operation Maintenance Checks & Services on Hydraulic Brake System

- Before-Operation Maintenance Checks & Services, Checks & Services on Steering, Accelerator, Transmission & Brake Controls
- Before-Operation Maintenance Checks & Services on the M27 Periscope
- Perform Before-Operation Checks & Services on the Tank Drain Valves
- Perform Before-Operation Maintenance Checks & Services on Drivers Thermal Viewer
- After-Operation Maintenance Checks & Services on Driver's Thermal Viewer
- Place Turret into Power Operation
- Remove and Install the M27 Periscope
- Remove and Install Driver's Thermal Viewer
- Place the Driver's Thermal Viewer into Operation

PERFORM DURING OPERATION MAINTENANCE CHECKS & SERVICES

- Perform During Operations Maintenance Checks & Services, Maintenance Checks & On Steering, Accelerator, Shift & Brake Controls
- Perform Main Gun Prepare-to-Fire Procedures from the Driver's Position
- Monitor Tank Instruments, Gages and Warning Lights

MAINTAINS & OPERATES COMMUNICATION EQUIPMENT

- Performs Operator Maintenance on Tank External Phone
- Place a Tank External Phone into Operation
- Operate Vehicular Intercommunications Equipment
- Prepare Combat Vehicle Crewman's Helmet (CVC) for Operation
- Perform Operator Maintenance on Communication Equipment

AFTER-OPERATIONS MAINTENANCE CHECKS & SERVICES

- After-Operations Maintenance Checks & Services on Tank Instruments, Gages & Warning Lights (Engine Running)
- Performs After-Operation Maintenance Checks & Services on Basic Issue Items

TARGET ACQUISITION

- o Acquire Ground Targets (Day)
- o Recognize and Identify Threat Weapons from Front, Side and Hull Down Views
- o Recognize and Identify Friendly Weapons from Front, Side and Hull Down Views
- o Acquire Ground and Airborne Targets and Report Them to TC
- o Recognize Smoke, Glint, Dust, Flash and Movement Cues to Possible Threat Activity
- o Detect Concealed Personnel, Vehicle, Aircraft and Weapon Threats
- o Discriminate Among Hostile and Friendly Elements
- o Discriminate Among Target Types; Discriminate Among Armored, Lightly Armored and Area Targets
- o Make Acquisition Reports
- o Recognize the Most Vulnerable Areas of Threat Tanks
- o Acquire Targets and Rank Them, the Most Dangerous Target First

TANK OPERATION PROCEDURES & DRIVING PERFORMANCE

- o Start and Stop Tank Engine
- o Start Tank Engine by Towing
- o Start Tank Engine by Auxiliary Power-Slave Start
- o Operate Tank in Neutral Steer
- o Drive Tank Over Varied Terrain with Driver's Hatch in the Open/Closed Position
- o Operate Tank Across a Water Obstacle
- o Respond to Ground Guide Signals While Driving a Tank
- o Accelerate, Decelerate, and Brake Smoothly
- o Maintain Correct Speeds
- o Use Driver's Night Vision Equipment
- o Drive Tank Using the Land Navigation System

o Negotiate a Narrow Shallow Ditch

o Negotiate Over Slight to High Elevations

o Move Through a Small Stream or Water Hole

o Negotiate a Wide Shallow Ditch

o Drive Following Correct Road March Procedures

o Drive Through Wooded Areas

o Climb Tank Over a Short, Steep Elevation

c Move Through a Narrow Defile

o Move Across a Narrow Bridge

o Move into and out of Restricted Areas (Motor Pools, Assembly Areas, Narrow Trails)

o Cross Vertical or Near Vertical Obstacles

o Approach, Ford, and Exit Correctly from Streams

o Ascend and Descend a Steep Hill

o Cross Deep Ditches or Gullies

o Drive Over Soft Marsh Areas

o Perform all Driving Tasks in the Closed Hatch Mode

o Drive Tank on Varied Road Surfaces (Pavement, Gravel, Dirt, Etc.)

o Drive Tank on Varied Soil Compositions (Muddy, Sand, Soft Dirt, Etc.)

o Drive Tank Under Black-Out Drive Conditions

o Drive Tank Following Night Flashlight Signals

o Drive Tank Following Groundguide Arm and Hand Signals

o Move Tank Over Moderately Uneven Terrain and Among Widely Spaced Obstacles

o Become Familiar with Acceleration, Deceleration and Turning Characteristics

o Negotiate Slopes

- Move Tank Up, Down and Across Slopes at Maximum Safe Speed

- Recognize Response in Acceleration and Steering to Various Slopes and Surfaces

- Negotiate Obstacles

- Recognize Logs, Ditches, Walls, Trees, Brush; Negotiate Obstacles

- Recognize Response of Tank to Movement Over and Through Obstacles

- Recognize Obstacles that cannot be Negotiated

- Negotiate Various Terrain Surfaces

- Negotiate Hard, Soft, Sandy, Icy, Muddy, Swamp, Snow Surfaces

- Recognize Response of Tank on Each Surface

- Operate Tank in Limited Visibility Over Various Surfaces and Among Various Obstacles

- Operate Tank in Fog, Rain, Smoke and Darkness by Direct Visual Reference

- Recognize Surface and Obstacle Characteristics in Limited Visibility

- Interpret Infra-Red and Night Vision System Images in Moving Tank Over and Among Various Surfaces and Obstacles

- Recognize Images with Respect to Obstacle and Surface Effects on Tank Movement

- Back Tank with Guidance from Commander

- Control Speed to Minimize Stopping Distance; Recognize Effects of Reverse Movement and Turning in Visual Scene

TERRAIN APPRECIATION

- Recognize Areas of Possible Threat Deployment; Evaluate Cover and Concealment Available in Battle Area; Correlate Briefing and Communications Information with Terrain Characteristics; Evaluate Signs of Current or Past Threat Activity.

- Recognize Possible Avenues of Approach and Fields of Fire for Potential Threats; Evaluate Load-Bearing Characteristics of Terrain, Evaluate Obstacles, Evaluate Terrain and Cultural Features Available for Threat Concealment; Correlate Information about Threat Objectives with Characteristics of the Battle Area.

- Recognize Possible Routes to the Objective. Evaluate Loadbearing, Obstacle Quality of Terrain; Recognize Areas of Cover and Concealment; Correlate Terrain Characteristics with Deployment of Threat and Friendly Elements; Select Routes and Engagement Procedures for Optimum Utilization of Support Elements and Minimum Vulnerability from Possible or Indicated Hostile Areas.

TACTICAL DRIVING

- Select Routes for Movement Capable of Supporting Tank, Containing Maximum Cover and Concealment; Select Route with Obstacles within Capability of the Tank. Compare Terrain Surfaces, Obstacles and Features with Known Tank Capabilities and with Major Elements of the Tactical Situation; Recognize Landmarks Defining the Objective and the Designated Route and Recognize Cues to the Deployment of Friendly and Hostile Elements.

- Select Areas Affording Covered or Concealed Firing Positions; Identify Areas Along Route Affording Smooth Routes for Stable Firing; Maintain Surveillance of Area Along Route; Prepare to Move into Covered or Concealed Position for Firing.

- Identify Secure Exit Routes from Firing Positions; Base Selection of Exits on the Tactical Situation and on the Condition of the Terrain at that Time.

- Detect and Report Targets, Signs of Target Activity.

- Modify Route to Maintain Security with Respect to Sensed Threats, Threat Activity, within Limits established by Tank Commander.

- Maintain Turret Stability within Practical Limits during Movement, Turning, Stopping.

DRIVING PERFORMANCE DURING TACTICAL MANEUVERS & FIRING ENGAGEMENTS

- Perform Evasive Maneuvers Upon Enemy Contact

- Move Vehicle into Defilade Firing Position upon Enemy Contact

- Perform Correct Driving Procedures during Main Gun Engagements (Stationary Target/Stationary Tank)
- Perform Correct Driving Procedures During Main Gun Engagements (Stationary Target/Stationary Tank)
- Perform Correct Driving Procedures During Main Gun Engagements (Moving Target/Moving Tank)
- Perform Correct Driving Procedures During Coax Engagements (Stationary Target/Stationary Tank)
- Perform Correct Driving Procedures During Coax Engagements (Stationary Target/Moving Tank)
- Perform Correct Driving Procedures During Coax Engagements (Moving Target/Moving Tank)
- Perform Correct Driving Procedures During Caliber .50 Engagements (Stationary Target/Stationary Tank)
- Perform Correct Driving Procedures During Caliber .50 Engagements (Stationary Target/Moving Tank)
- Perform Correct Driving Procedures During Caliber .50 Engagements (Moving Target/Moving Tank)
- Perform Correct Driving Procedures When Tank Commander Employs the Smoke Grenade Launchers
- Employ Correct Driving Procedures when Loader Fires the Loaders Weapon (Stationary Target/Stationary Tank)
- Employ Correct Driving Procedures when Loader Fires the Loader's Weapon (Stationary Target/Moving Tank)
- Employ Correct Driving Procedures when Loader Fires the Loaders Weapon (Moving Target/Moving Tank)
- Move Into Prepared Night Firing Positions
- Select a Route Providing a Stable Firing Platform for Firing in the Stabilized Mode
- Sense Rounds
- Select Firing Positions
- Move Tank into Hull-Down Positions
- Move Tank into Turret-Down Positions

4.4.5 Crew Interactive Tasks. Most operational tasks performed by the crew of the M60A3 are interactive; each individual action is dependent to some degree on the performance of some other crew member, and each action has some effect on the rest of the crew. For these reasons, each crew member learns enough about the job of each other member to permit him to anticipate the effects of each person's actions on his own tasks, and to anticipate the ways in which his tasks affect the rest of the crew.

The most intimate crew interactions occur between the tank commander and the gunner, and between the tank commander and the driver, as the tank is used to engage and destroy targets, and as it is moved around the battle area. Much of the activity in the tank is organized around a standardized fire command format. The fire command provides precise information to each member of the crew which permits him to do his job rapidly, accurately, and in the proper relationship to the job of each other member of the crew.

When the tank commander makes the initial fire command, he alerts the crewmember who will have to act, usually the gunner. The initial fire command also alerts the driver to the fact that an engagement is imminent. Immediately after the alert, the tank commander identifies the ammunition and/or weapon to be employed and he describes the target, its direction and range. When main gun ammunition is identified, the loader searches the ready rack for the proper round, removes and loads it, announcing "up" to the gunner, who has indexed the ammunition in the ballistic computer. At the same time, as the tank commander announces the target type and location, he slews the turret to bring the target into the gunner's field of view. The driver's responsibility is to locate the target, or its general direction, and steer the tank to a position where its visibility from the target is minimized, while the target still remains visible from the crew positions in the turret.

As the tank commander slews the turret toward the target, he uses the laser range finder to supply an accurate range input to the computer, unless his range estimate indicates that the target can be engaged with the battlesight setting. As the round is loaded, the gunner lays his crosshairs on it and fires; the loader prepares to load a subsequent round, and the rest of the crew watches to sense and adjust fire as required for target effect. At the same time, the driver prepares to move the tank to a new firing position, or to continue maneuvers toward the objective.

Tables 4-6 through 4-9 present typical crew interactive tasks for four types of engagements, and the manner in which these procedures are integrated for rapid and accurate performance. The tables are organized to illustrate sequences of actions along a time line. In actual practice, any crewmember can initiate an engagement, if he sees a target or a good indication of target presence; Tables 4-6 through 4-9 assume that the tank commander initiates the engagement.

TABLE 4-6 INTERACTIVE CREW TASKS,-(MAIN GUN, PRECISION ENGAGEMENT)

TANK COMMANDER	GUNNER	LOADER	DRIVER
LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH: HATCH OPEN/POPPED- USES UNAIDED VISION, OR BINOCULARS HATCH CLOSED- USES UNAIDED VISION OR BINOCULARS TO VIEW THROUGH VISION BLOCKS	LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH BY MOVING TURRET POWER CONTROLS AND LOOKING THROUGH GUNNER'S PERISCOPE	LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH EITHER WITH HATCH OPEN AND USING UNAIDED VISION OR THROUGH THE LOADER'S PERISCOPE WITH THE HATCH CLOSED GIVES TARGET ACQUISITION REPORT	LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH USING UNAIDED VISION WITH HATCH OPENED OR THROUGH THE DRIVER'S PERISCOPES WITH THE HATCH CLOSED DRIVES TANK KEEPING THE FRONT OF THE TANK TOWARD THE TARGET
LOCATES A TARGET IN AREA OF SURVEILLANCE OR OBTAINS A TARGET ACQUISITION REPORT FROM ANOTHER CREWMEMBER AND LOCATES TARGET REPORTED	WAITS FOR COMDR. TO INITIATE HIS FIRE COMMAND BY SAYING "GUNNER"	WAITS FOR COMDR. TO SAY "GUNNER"	WAITS FOR COMDR. TO SAY "GUNNER"
° IDENTIFIES TARGET			
° SAYS, "GUNNER"	TURNS MAIN GUN SWITCH TO "ON" POSITION WAITS FOR COMDR. TO SAY, "ANTI-TANK"		
° SAY'S "ANTI-TANK"	WAITS FOR COMDR. TO SAY "HEP"	WAITS FOR COMDR. TO SAY "HEP"	
DETERMINES AMMUNITION FOR THE SPECIFIC TARGET BASED ON TARGET TYPE, RANGE AND AMMUNITION AVAILABILITY/ RESUPPLY CONSTRAINTS			
DETERMINES ALIGNMENT OF MAIN GUN WITH LOCATION OF TARGET	LOCATES TARGET IN AREA OF SURVEILLANCE		
° SAY'S "HEP"	INDEXES HEP AMMUNITION INTO COMPUTER	LOCATES HEP ROUND IN THE READY RACK UNLOCKS READY RACK REMOVES HEP ROUND FROM READY RACK LOADS HEP ROUND INTO BREECH	
WAITS FOR GUNNER TO SAY "IDENTIFIED" LOOKS THROUGH RANGEFIND-	PLACES TELESCOPE SELECTION LEVER IN APDS/HEP POSITION	OBSERVES TO SEE THAT	

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2			LOADS HEP ROUND INTO BREECH		
	WAITS FOR GUNNER TO SAY "IDENTIFIED" LOOKS THROUGH RANGEFINDER- RANGES ON TARGET ALIGNS RANGEFINDER RETICLE ONTO CENTER OF TARGET	PLACES TELESCOPE SELECTION LEVER IN APDS/HEP POSITION LOOKS THROUGH TELESCOPE (SEARCHING FOR TARGET TO APPEAR) CHECKS TO SEE THAT THE APDS/HEP RETICLE IS IN THE CORRECT POSITION IDENTIFIES TARGET ° SAY'S"IDENTIFIED"	OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS COMPLETELY CLOSED		
	DETERMINES CORRECT RANGE READOUT	WAITS FOR COMDR. TO RELINQUISH TURRET POWER CONTROLS LISTENS FOR COMDR. TO SAY "ONE SIX HUNDRED" OR NOTES RANGE READOUT ON COMPUTER	STANDS CLEAR OF BREECH		
.3	RELINQUISHES TURRET AND GUN CONTROLS TO GUNNER INDEXES RANGE INTO COMPUTER OR SAY'S "ONE SIX HUNDRED" SAY'S "DRIVER STOP"	LISTENS FOR COMDR. TO SAY "DRIVER STOP" SETS MOVING/STATIONARY SWITCH ON AMMO SELECT UNIT TO STATIONARY MOVES 1600m RANGE LINE WITH POWER CONTROLS TO CENTER OF TARGET VUNERABILITY AND MAKES A PRECISE LAY LISTENS FOR LOADER TO SAY "UP" WAITS FOR COMDR. TO SAY "FIRE"	PLACES SAFETY SWITCH IN "FIRE" POSITION	WAITS FOR COMDR. TO SAY "DRIVER STOP"	
	WAITS FOR LOADER TO SAY, "UP" WAITS FOR DRIVER TO BRING TANK TO A SMOOTH HALT				

.3		LISTENS FOR LOADER TO SAY "UP" WAITS FOR COMDR. TO SAY "FIRE"			
	WAITS FOR LOADER TO SAY, "UP" WAITS FOR DRIVER TO BRING TANK TO A SMOOTH HALT		SAY'S "UP"	BRINGS TANK TO A SMOOTH GRADUAL HALT APPLIES BRAKES FOR FIRING	
	SAY'S "FIRE" WAITS FOR GUNNER TO SAY "ON THE WAY" LOOKS AT TARGET WITH UN-AIDED VISION, BINOCULARS, COMDR!S WEAPON SIGHT, OR THERMAL SIGHT OBSERVES STRIKE OF ROUND AND MAKES A MENTAL SENSING WAITS FOR GUNNER TO SAY WHAT HIS RANGE SENSING IS	SAY'S "ON THE WAY" SQUEEZES MAIN GUN FIRING TRIGGER CONCENTRATES ON TARGET NOTING THE POINT OF THE SIGHT RETICLE WHERE THE TRACER OR BURST APPEARS AS IT PASSES, STRIKES SHORT OF, OR HITS THE TARGET RELAYS ON TARGET USING POWER CONTROLS SAYS WHAT RANGE SENSING IS MADE (IE. SHORT, OVER, ETC.) SAYS "TARGET" IF TARGET IS HIT	WAITS FOR GUNNER TO SAY "ON THE WAY" WAITS FOR MAIN GUN TO FIRE TURNS VENTILATING BLOWER SWITCH TO "ON" POSITION	WAITS FOR MAIN GUN TO FIRE	
.4	IF TARGET IS NOT HIT, DETERMINES FROM GUNNER'S SENSING WETHER TO ALLOW GUNNER TO ADJUST FIRE, TO ISSUE A SUBSEQUENT FIRE COMMAND OR TO FIRE FROM THE COMDR'S POSITION	MAINTAINS CORRECT SIGHT PICTURE USING TURRET POWER CONTROLS USING GUN CONTROLS, IMMED-IATELY MOVES BOT POINT ON RETICLE TO THE CENTER OF TARGET MASS WAITS FOR COMDR. TO SAY "CEASE FIRE" OR ISSUE A SUBSEQUENT FIRE COMMAND WAITS FOR LOADER TO SAY "UP"	LOADS 2ND OF HEP STANDS CLEAR OF BREECH		
	ISSUES SUBSEQUENT FIRE COMMAND OR SAYS, "FROM MY POSITION" DETERMINES WEAPON EFFECT ON TARGET	SAYS, "ON THE WAY" SQUEEZES MAIN GUN FIRING TRIGGER	° SAY'S " UP " CONTINUES TO LOAD HEP AMMUNITION UNTIL COMDR		

COMDR'S WEAPON SIGHT, OR THERMAL SIGHT	SIGHT RETICLE WHERE THE TRACER OR BURST APPEARS AS IT PASSES, STRIKES SHORT OF, OR HITS THE TARGET		
OBSERVES STRIKE OF ROUND AND MAKES A MENTAL SENSING			
WAITS FOR GUNNER TO SAY WHAT HIS RANGE SENSING IS	RELAYS ON TARGET USING POWER CONTROLS		
	SAYS WHAT RANGE SENSING IS MADE (IE. SHORT,OVER, ETC.) SAYS "TARGET" IF TARGET IS HIT		
IF TARGET IS NOT HIT, DETERMINES FROM GUNNER'S SENSING WETHER TO ALLOW GUNNER TO ADJUST FIRE,TO ISSUE A SUBSEQUENT FIRE COMMAND OR TO FIRE FROM THE COMDR'S POSITION	MAINTAINS CORRECT SIGHT PICTURE USING TURRET POWER CONTROLS	LOADS 2ND OF HEP	
	USING GUN CONTROLS,IMMEDIATELY MOVES BOT POINT ON RETICLE TO THE CENTER OF TARGET MASS	STANDS CLEAR OF BREECH	
	WAITS FOR COMDR. TO SAY "CEASE FIRE" OR ISSUE A SUBSEQUENT FIRE COMMAND		
	WAITS FOR LOADER TO SAY "UP"		
ISSUES SUBSEQUENT FIRE COMMAND OR SAYS, "FROM MY POSITION"	SAYS, "ON THE WAY" SQUEEZES MAIN GUN FIRING TRIGGER	° SAY'S " UP "	
DETERMINES WEAPON EFFECT ON TARGET		CONTINUES TO LOAD HEP AMMUNITION UNTIL COMDR. CHANGES AMMUNITION OR SAYS, "CEASE FIRE"	
SAYS, "CEASE FIRE"			MOVES TANK FORWARD AS QUICKLY AS POSSIBLE

CONDITIONS

CREW MEMBER FIRING: GUNNER

VEHICLE MODE: MOVING, STABILIZED

VISIBILTY: DAY

FIRE CONTROL INSTRUMENTS: RANGEFINDER, GUNNER'S TELESCOPE

FIRING MODE: MOVING TO A MOMENTARY HALT

TARGET: ANTI-TANK, STATIONARY

RANGE: 1600 METERS

AMMUNITION: HEP

TABLE 4-7 INTERACTIVE CREW TASKS, - (.50 CALIBER MACHINEGUN ENGAGEMENT)

TANK COMMANDER	GUNNER	LOADER	DRIVER
LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH: HATCH OPEN/POPPED--USES UNAIDED VISION OR BINOCULARS HATCH CLOSED -- USES UNAIDED VISION OR BINOCULARS	LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH BY MOVING TURRET POWER CONTROLS AND LOOKING THROUGH THE GUNNER'S PERISCOPE	LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH EITHER WITH HATCH OPEN AND USING UNAIDED VISION OR THROUGH THE LOADER'S PERISCOPE WITH THE HATCH CLOSED	LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH EITHER WITH HATCH OPEN AND USING UNAIDED VISION OR THROUGH THE DRIVER'S PERISCOPE WITH THE HATCH CLOSED
LOCATES A TARGET IN AREA OF SURVEILLANCE OR OBTAINS A TARGET ACQUISITION REPORT FROM ANOTHER CREW-MEMBER AND LOCATES REPORTED TARGET IDENTIFIES TARGET	LISTENS FOR COMDR TO GIVE A FIRE COMMAND	LISTENS FOR COMDR TO GIVE A FIRE COMMAND	LISTENS FOR COMDR TO GIVE A FIRE COMMAND
DETERMINES WHICH WEAPON SYSTEM HE WILL EMPLOY AGAINST THE TARGET			SELECTS GROUND TO DRIVE OVER WHICH WILL GIVE AS SMOOTH AND STABLE A FIRING PLAT-FORM AS POSSIBLE
SAYS, "CALIBER FIFTY." COMDR TELLS DRIVER TO PLACE THE TANK IN A TURRET OR HULL-DOWN FIRING POSITION TURNS CUPOLA ELECTRIC POWER CONTROL TO "ON" CHECKS TO SEE THAT CUPOLA POWER SWITCH IS IN THE ON POSITION	OBSERVES TARGET AREA THROUGH GUNNER'S PERI-SCOPE OR INFINITY SIGHT, IF POSSIBLE CONTINUES TO OBSERVE FOR TARGETS IN ASSIGNED SECTOR OF SEARCH	OBSERVES TARGET AREA USING UNAIDED VISION WITH THE HATCH OPEN OR WITH THE HATCH CLOSED OBSERVES THROUGH THE LOADER'S PERISCOPE	WAITS FOR COMDR TO TELL HIM TO SELECT A TURRET OR HULL-DOWN FIRING POSITION SELECTS THE BEST FIRING POSITION AVAIL-ABLE DRIVES TANK INTO FIRING POSITION KEEPING FRONT OF TANK ORIENTED TOWARD TARGET
TRAVERSE CUPOLA SO THAT MACHINE GUN IS LAID FOR DIRECTION ELEVATED OR DEPRESSES MACHINE GUN SO THAT CORRECT RANGE LINE IS			

MACHINE GUN SO THAT CORRECT RANGE LINE IS LOCATED ON NEAR EDGE OF TARGET PLACES RATE OF FIRE SELECTOR IN LOW FIRE RATE POSITION CHECKS TO MAKE SURE FIRE SELECTOR SWITCH IS IN LOW FIRE RATE POSITION TURNS MACHINE GUN SAFETY TO "FIRE" TURNS GUN FIRING SAFETY SWITCH TO "ON"			
ESTIMATES RANGE TO TARGET (USES RECOGNITION METHOD OF RANGE DETERMINATION) LAYS BALLISTIC RETICLE ON NEAR EDGE OF TARGET			BRINGS TANK TO SMOOTH GRADUAL HALT
PUSHES FIRING TRIGGER (FIRES 15-20 ROUND BURSTS) EMPLOYS "Z" PATTERN OF FIRE AGAINST THE TROOPS, IF THEY OFFER A WIDE FRONTAL TARGET			
WATCHES WHERE TRACERS AND ROUNDS STRIKE	SENSES STRIKE OF TRACERS OR ROUNDS	SENSES STRIKE OF TRACERS OR ROUNDS	OBSERVES TARGET AREA AND SENSES TRACERS AND STRIKE OF ROUNDS
LISTENS FOR ANY CREW MEMBER TO ASSIST IN GIVING FIRE ADJUSTMENT DIRECTION (EX: DROP IT, RAISE IT, ETC.) ADJUSTS ELEVATION AND DEFLECTION USING THE CUPOLA POWER CONTROLS	AIDS IN FIRE ADJUSTMENT	AIDS IN FIRE ADJUSTMENT	AIDS IN FIRE ADJUSTMENT
DETERMINES WEAPON EFFECT ON TARGET SAYS, "TARGET, CEASE FIRE."	WAITS FOR FURTHER ORDERS FROM THE COMDR	WAITS FOR FURTHER ORDERS FROM THE COMDR	WAITS FOR FURTHER ORDERS FROM THE COMDR

CONDITIONS

NITION METHOD OF RANGE DETERMINATION)			GRADUAL HALT
LAYS BALLISTIC RETICLE ON NEAR EDGE OF TARGET			
PUSHES FIRING TRIGGER (FIRES 15-20 ROUND BURSTS) EMPLOYS "Z" PATTERN OF FIRE AGAINST THE TROOPS, IF THEY OFFER A WIDE FRONTAL TARGET			
WATCHES WHERE TRACERS AND ROUNDS STRIKE	SENSES STRIKE OF TRACERS OR ROUNDS	SENSES STRIKE OF TRACERS OR ROUNDS	OBSERVES TARGET AREA AND SENSES TRACERS AND STRIKE OF ROUNDS
LISTENS FOR ANY CREW MEMBER TO ASSIST IN GIVING FIRE ADJUSTMENT DIRECTION (EX: DROP IT, RAISE IT, ETC.) ADJUSTS ELEVATION AND DEFLECTION USING THE CUPOLA POWER CONTROLS	AIDS IN FIRE ADJUSTMENT	AIDS IN FIRE ADJUSTMENT	AIDS IN FIRE ADJUSTMENT
DETERMINES WEAPON EFFECT ON TARGET SAYS, "TARGET, CEASE FIRE."	WAITS FOR FURTHER ORDERS FROM THE COMDR	WAITS FOR FURTHER ORDERS FROM THE COMDR	WAITS FOR FURTHER ORDERS FROM THE COMDR

CONDITIONS

CREW MEMBER FIRING: TANK COMMANDER

VEHICLE MODE: MOVING, STABILIZED

VISIBILITY: DAY

FIRE CONTROL INSTRUMENTS: COMDR'S PERISCOPE (DAY)

FIRING MODE: MOVING TO A STATIONARY POSITION

TARGET: TROOPS

RANGE: LESS THAN 1600 METERS

,3

TABLE 4-8 INTERACTIVE CREW TASKS, - (COAXIAL MACHINEGUN ENGAGEMENT)

TANK COMMANDER	GUNNER	LOADER	DRIVER
LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH: HATCH OPEN/POPPED -- USES UNAIDED VISION OR BINOCULARS HATCH CLOSED -- USES UNAIDED VISION OR BINOCULARS TO VIEW THROUGH VISION BLOCKS	LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH BY MOVING TURRET POWER CONTROLS AND LOOKING THROUGH GUNNER'S PERISCOPE	LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH WITH HATCH OPEN AND USING UNAIDED VISION OR THROUGH THE LOADER'S PERISCOPE WITH THE HATCH CLOSED	LOOKS FOR TARGETS IN ASSIGNED SECTOR OF SEARCH USING UNAIDED VISION WITH HATCH OPEN OR THROUGH DRIVER'S PERISCOPES WITH HATCH CLOSED
LOCATES A TARGET IN AREA OF SURVEILLANCE OR OBTAINS A TARGET ACQUISITION REPORT FROM ANOTHER CREW-MEMBER AND LOCATES TARGET REPORTED	WAIT FOR COMDR TO SAY, "GUNNER"	WAITS FOR COMDR TO SAY, "GUNNER"	WAITS FOR COMDR TO SAY, "GUNNER"
IDENTIFIES TARGET SAYS, "GUNNER" SAYS, "DUG-IN TROOPS" SAYS, "COAX"			
DETERMINES WHICH WEAPON SYSTEM HE WILL EMPLOY AGAINST TARGET	WAIT FOR COMDR TO SAY, "COAX"	WAIT FOR COMDR TO SAY, "COAX"	WAITS FOR COMDR TO SAY, "COAX"
	TURN COAX SWITCH TO ON POSITION	CHECKS TO MAKE SURE COAX IS LOADED	
PRESSES HEP ON AMMUNITION SELECT UNIT	CHECKS TO SEE THAT COMDR SELECTS HEP AMMUNITION		
	SELECTS HEP AMMUNI-TION IF COMDR DOES NOT	PLACES SAFETY IN FIRE POSITION	WAITS FOR COMDR TO SAY, "DUG-IN TROOPS"
DETERMINES ALIGN-MENT OF MAIN GUN WITH LOCATION OF TARGET	CHECKS TO SEE THAT THE MOVING/STATIONARY SWITCH ON THE AMMO SELECT UNIT IS SET ON MOVING		SELECTS GROUND TO TRAVEL OVER WHICH PROVIDES THE SMOOTHEST AND MOST STABLE FIRING PLATFORM FOR THE GUNNER
WAITS FOR LOADER [illegible]	[illegible]		[illegible]

7	WAITS FOR LOADER TO SAY, "UP" TRAVERSE TURRET FOR DIRECTION USING COMDR'S OVERRIDE LAYS MAIN GUN USING COMDR'S OVERRIDE ALIGNS RANGEFINDER RETICLE ON CENTER OF TARGET AREA ESTIMATES RANGE TO TARGET (USES RECOGNITION METHOD OF RANGE DETERMINATION) LISTENS FOR REPORTS OF ADVERSE TERRAIN CONDITIONS FROM DRIVER	SIGHTS THROUGH THE UNITY POWER WINDOW OF THE GUNNER'S PERISCOPE		MAINTAINS A STEADY SPEED OF 10-15 MPH	
.3	INDEXES 500M INTO THE COMPUTER WAITS FOR GUNNER TO SAY, "IDENTIFIED" RELINQUISHES TURRET AND GUN CONTROLS TO GUNNER	RECOGNIZES ANNOUNCED TARGET AS IT APPEARS IN FIELD OF VIEW SAYS, "IDENTIFIED" LAYS FRONT EDGE OF TARGET AREA IN THE CENTER OF THE AIMING CIRCLE USING POWER CONTROLS WAITS FOR LOADER TO SAY, "UP" WAITS FOR COMDR TO SAY, "FIRE"	SAYS, "UP" WAITS FOR COMDR TO SAY, "FIRE" WAITS FOR GUNNER TO SAY, "ON THE WAY" WAITS FOR COAX TO FIRE	DRIVES TANK KEEPING THE FRONT OF THE TANK TOWARDS THE TARGET WAITS FOR COMDR TO SAY, "FIRE" LISTENS FOR ANY DRIVING COMMANDS FROM COMDR KEEPS GUNNER INFORMED OF ANY OBSTACLES IN THE TANK'S PATH WHICH MIGHT AFFECT GUN ACCURACY, FOR EXAMPLE: (SAYS, "DEPRESSION OR TURN.") TIMES HIS GEAR AND DIRECTION CHANGES SO THAT THEY OCCUR IMMEDIATELY AFTER FIRING SO THAT IT WILL NOT INTERFERE WITH ACCURACY	
	LOOKS AT TARGET WITH UNAIDED VISION, BINOCULARS, COMDR'S WEAPON SIGHT,	ASSUMES THAT HE HAS A STABLE FIRING PLATFORM UNLESS DRIVER SAYS OTHERWISE	OBSERVES FUNCTIONING OF MACHINE GUN WHILE IT FIRES IF A MALFUNCTION	AFTER OBSTACLE HAS BEEN NEGOTIATED, SAYS, "STEADY" TO TELL GUNNER HE AGAIN HAS A STABLE FIRING PLATFORM	

			DIRECTION CHANGES SO THAT THEY OCCUR IMMEDIATELY AFTER FIRING SO THAT IT WILL NOT INTERFERE WITH ACCURACY
LOOKS AT TARGET WITH UNAIDED VISION, BINOCULARS, COMDR'S WEAPON SIGHT, RANGEFINDER, OR THERMAL SIGHT SAYS, "FIRE" WAITS FOR GUNNER TO SAY "ON THE WAY" WATCHES TO SEE WHERE TRACERS AND ROUNDS STRIKE	ASSUMES THAT HE HAS A STABLE FIRING PLATFORM UNLESS DRIVER SAYS OTHERWISE SAYS, "ON THE WAY" SQUEEZE FIRING TRIGGER ON POWER CONTROL HANDLES FIRES 20-25 ROUND BURSTS MOVES TURRET POWER CONTROLS TO COMPLETE "Z" PATTERN IN TURRET AREA OBSERVES STRIKE OF TRACERS AND ROUNDS IN TARGET AREA	OBSERVES FUNCTIONING OF MACHINE GUN WHILE IT FIRES IF A MALFUNCTION OCCURS WHILE THE TANK IS MOVING, SAYS, "STANDBY REQUIRED" SWITCHES EMERGENCY SHUTOFF TO "STANDBY MODE" PLACES MACHINE GUN IN SAFE CORRECTS MALFUNCTION SAYS, "STAB" PLACES EMERGENCY SHUTOFF TO "STABILIZED MODE" PLACES SAFETY IN FIRE POSITION SAYS, "UP"	AFTER OBSTACLE HAS BEEN NEGOTIATED, SAYS, "STEADY" TO TELL GUNNER HE AGAIN HAS A STABLE FIRING PLATFORM OBSERVES TARGET AREA SENSES STRIKE OF TRACERS AND ROUNDS
OBSERVES TO SEE IF GUNNER EMPLOYS THE "Z" FIRING PATTERN. IF NOT, DIRECTS GUNNER TO DO SO GIVES FIRE ADJUSTMENT COMMANDS DETERMINES WEAPON EFFECTS ON TARGET SAYS, "CEASE FIRE"	CONTINUES TO FIRE AND ADJUST UNTIL COMDR SAYS, "CEASE FIRE" OR ISSUES OTHER FIRE COMMANDS	CONTINUES TO MONITOR MACHINE GUN FIRING OPERATIONS UNTIL COMDR SAYS, "CEASE FIRE OR ISSUE OTHER COMMANDS	WAITS FOR COMDR TO SAY "CEASE FIRE" OR ISSUES OTHER COMMANDS

CONDITIONS

CREW MEMBER FIRING: GUNNER

VEHICLE MODE: MOVING STABALIZED

-3

WAITS FOR GUNNER TO SAY "ON THE WAY" WATCHES TO SEE WHERE TRACERS AND ROUNDS STRIKE	TRIGGER ON POWER CONTROL HANDLES FIRES 20-25 ROUND BURSTS MOVES TURRET POWER CONTROLS TO COMPLETE "Z" PATTERN IN TURRET AREA OBSERVES STRIKE OF TRACERS AND ROUNDS IN TARGET AREA	SWITCHES EMERGENCY SHUTOFF TO "STANDBY MODE" PLACES MACHINE GUN IN SAFE CORRECTS MALFUNCTION SAYS, "STAB" PLACES EMERGENCY SHUT-OFF TO "STABILIZED MODE" PLACES SAFETY IN FIRE POSITION SAYS, "UP"	TRACERS AND ROUNDS
OBSERVES TO SEE IF GUNNER EMPLOYS THE "Z" FIRING PATTERN. IF NOT, DIRECTS GUNNER TO DO SO GIVES FIRE ADJUSTMENT COMMANDS DETERMINES WEAPON EFFECTS ON TARGET SAYS, "CEASE FIRE"	CONTINUES TO FIRE AND ADJUST UNTIL COMDR SAYS, "CEASE FIRE" OR ISSUES OTHER FIRE COMMANDS	CONTINUES TO MONITOR MACHINE GUN FIRING OPERATIONS UNTIL COMDR SAYS, "CEASE FIRE OR ISSUE OTHER COMMANDS	WAITS FOR COMDR TO SAY "CEASE FIRE" OR ISSUES OTHER COMMANDS

CONDITIONS

CREW MEMBER FIRING: GUNNER

VEHICLE MODE: MOVING STABALIZED

VISIBILITY: DAY

FIRE CONTROL INSTRUMENTS: INFINITY SIGHT

FIRING MODE: MOVING

TARGET: DUG-IN TROOPS

RANGE: 500 METERS

TABLE 4-9 INTERACTIVE CREW TASKS (MAIN GUN-RANGE CARD ENGAGEMENT)

TANK COMMANDER	GUNNER	LOADER	DRIVER
COMDR RECEIVES A WARNING OF APPROACHING ENEMY. THIS IS USUALLY GIVEN BY: GROUND SURVEILLANCE PERSONNEL SIGNAL DEVICES GROUND SENSOR TEAMS AERIAL FLARES LISTENING POST PERSONNEL THE COMDR COULD ALSO DETECT THE ENEMY APPROACH BY ONE OF THE CREW MEMBERS ON WATCH USING THE NIGHT VISION EQUIPMENT ORGANIC TO THE TANK. RECEIVES TARGET ACQUISITION REPORT	WAITS FOR COMDR TO SAY, "GUNNER"	WAITS FOR COMDR TO SAY, "RANGECARD"	RECEIVES ALERT FROM OTHER CREWMEMBER AND PREPARES FOR TARGET ENGAGEMENT
ALERTS THE CREW OBTAINS FIRING DATA FROM RANGECARD CHECKS TO SEE THAT HEP IS INDEXED. CHECKS TO SEE THAT MOVING/STATIONARY SWITCH ON AMMO SELECT UNIT IS ON STATIONARY SAYS, "GUNNER" SAYS "FIVE ROUND PATTERN"	TURNS TURRET POWER SWITCH TO "ON". TURNS MAIN GUN SWITCH TO "ON" CHECKS TO SEE THAT MOVING/STATIONARY SWITCH ON AMMO SELECT UNIT IS ON STATIONARY		
SAYS, "RANGECARD"	WAITS FOR COMDR TO SAY, "HEP"	KNOWS THAT HEP AMMUNITION IS USED FOR FIRING A RANGECARD ENGAGEMENT. DETERMINE IF A ROUND OF HEP HAS BEEN PREVIOUSLY LOADED. IF NOT, PREPARES TO LOAD A ROUND OF HEP. CHECKS TO SEE THAT MAIN GUN SAFETY IS IN SAFE POSITION. LOCATES HEP	

.2			HEP HAS BEEN PREVIOUSLY LOADED. IF NOT, PREPARES TO LOAD A ROUND OF HEP. CHECKS TO SEE THAT MAIN GUN SAFETY IS IN SAFE POSITION. LOCATES HEP ROUNDS IN READY RACK. UNLOCKS READY RACK.		
	SAYS, PC'S (ARMORED) PERSONNEL CARRIERS) **SAYS "HEP"**	WAITS FOR COMDR TO SAY THE DEFLECTION READING	KNOWS THAT HEP AMMUNITION IS USED FOR FIRING A RANGECARD ENGAGEMENT. DETERMINE IF A ROUND OF HEP HAS BEEN PREVIOUSLY LOADED. IF NOT, PREPARES TO LOAD A ROUND OF HEP. CHECKS TO SEE THAT MAIN GUN SAFETY IS IN SAFE POSITION. LOCATES HEP ROUNDS IN READY RACK. UNLOCKS READY RACK		
	SAYS, "DEFLECTION TWO EIGHT HUNDRED"	CHECKS TO SEE THAT HEP HAS BEEN INDEXED TRAVERSES TURRET USING MANUAL CONTROLS UNTIL 2800R IS INDICATED ON THE AZIMUTH INDICATOR. SAYS, "DEFLECTION TWO EIGHT HUNDRED - RIGHT" SLIPS AZIMUTH INDICATOR GUNNER'S AID AND PLACES ZERO INDEX MARK ON 2800R WAITS FOR COMDR TO SAY THE QUADRANT ELEVATION READING	LIFTS AND LOADS 1ST HEP ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS FULLY CLOSED. STANDS CLEAR OF BREECH.		
.3	**WAITS FOR GUNNER TO READ BACK CORRECT DEFLECTION READING. WAITS FOR GUNNER TO READ BACK CORRECT ELEVATION QUADRANT READING** **SAYS, "QUADRANT PLUS TWO FIVE"** **INDEXES 1800m INTO THE RANGEFINDER** **SAYS, "RANGE ONE EIGHT HUNDRED"**	INDEXES PLUS TWO FIVE ON THE ELEVATION QUADRANT SAYS, "QUADRANT PLUS TWO FIVE" WAITS FOR COMDR TO SAY THE RANGE TO THE TARGET	OBSERVES TO SEE THAT ROUND IS FULLY CLOSED STANDS CLEAR OF BREECH		

13	SAYS, "QUADRANT PLUS TWO FIVE" INDEXES 1800m INTO THE RANGEFINDER SAYS, "RANGE ONE EIGHT HUNDRED" WAITS FOR LOADER TO SAY, "UP"	INDEXES PLUS TWO FIVE ON THE ELEVATION QUADRANT SAYS, "QUADRANT PLUS TWO FIVE" WAITS FOR COMDR TO SAY THE RANGE TO THE TARGET USING MANUAL CONTROLS-ELEVATES OR DEPRESSES MAIN GUN UNTIL BUBBLE IN QUADRANT IS CENTERED CHECKS TO SEE THAT 1800m HAS BEEN INDEXED INTO THE COMPUTER	OBSERVES TO SEE THAT ROUND IS FULLY CLOSED STANDS CLEAR OF BREECH		
H.	SAYS, "FIRE" WAITS FOR GUNNER TO SAY, "ON THE WAY"	KNOWS THAT THERE ARE TWO FIRING PATTERNS, ONE FOR TARGETS OVER 2000m AND ONE FOR TRAGETS 2000m OR LESS. FIRES CORRECT PATTERN. WAITS FOR LOADER TO SAY, "UP" SAYS, "ON THE WAY" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CONTROL HANDLE ADDS ONE MIL ON THE ELEVATION QUADRANT. RELEVELS BUBBLE USING MANUAL ELEVATION CONTROL HANDLE SAYS, "ON THE WAY" WAITS FOR LOADER TO SAY "UP" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CONTROL HANDLE DROPS 2 MILS ON THE ELEVATION QUADRANT ELEVATION CONTROL HANDLE WAITS FOR LOADER TO SAY "UP" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CONTROL HANDLE.	PLACES MAIN GUN SAFETY IN FIRE POSITION SAYS, "UP" WAITS FOR GUNNER TO SAY, "ON THE WAY" TURNS VENTILATING BLOWER SIWTCH TO ON POSITION LOADS 2ND ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS FULLY CLOSED. STANDS CLEAR OF BREECH. SAYS, "UP" WAITS FOR GUN TO FIRE LOADS 3RD ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS COMPLETELY CLOSED STANDS CLEAR OF BREECH SAYS, "UP" WAITS FOR GUN TO FIRE LOADS 4TH ROUND	DRIVER KEEPS HIS EYES CLOSED BETWEEN THE FIRING OF EACH ROUND IN ORDER TO RETAIN HIS NIGHT VISION	

	DROPS 2 MILS ON THE ELEVATION QUADRANT ELEVATION CONTROL HANDLE WAITS FOR LOADER TO SAY "UP" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CONTROL HANDLE. SAYS, "ON THE WAY" ADDS 1 MIL ON ELEVATION QUADRANT. RELEVELS BUBBLE USING MANUAL ELEVATION CONTROL HANDLE WAITS FOR LOADER TO SAY, "UP" USING MANUAL TRAVERSING CONTROLS-TRAVERSES TURRET 50 MILS TO THE RIGHT SAYS, "ON THE WAY" USING MANUAL TRAVERSING CONTROLS-TRAVERSES TURRET 100 MILS TO THE LEFT WAITS FOR LOADER TO SAY, "UP" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CONTROL HANDLE. SAYS, "END OF MISSION" WAITS FOR COMDR TO SAY "CEASE FIRE OR ISSUE OTHER COMMANDS"	ED AND BREECH IS COMPLETELY CLOSED STANDS CLEAR OF BREECH SAYS, "UP" WAITS FOR GUN TO FIRE LOADS 4TH ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS COMPLETELY CLOSED STANDS CLEAR OF BREECH SAYS, "UP" WAITS FOR GUN TO FIRE LOADS 5TH ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS FULLY CLOSED STANDS CLEAR OF BREECH SAYS, "UP" PLACES MAIN GUN SAFETY IN SAFE POSITION WAITS FOR COMDR TO SAY, "CEASE FIRE" OR ISSUE OTHER COMMANDS	
OBSERVES TARGET AREA FOR WEAPON EFFECTS. PREPARES TO ENGAGE TARGETS WITH DIRECT FIRE IF THEY SHOULD BECOME ILLUMINATED SAYS, "CEASE FIRE" AFTER THE 5TH ROUND IS FIRED.			DRIVER PREPARES TO START THE TANK ENGINE AS SOON AS THE FIRING PATTERN HAS BEEN COMPLETED AND BE PREPARED TO MOVE TO AN ALTERNATE FIRING POSITION UPON ORDERS FROM THE COMDR

CONDITIONS

CREW MEMBER FIRING: GUNNER FIRING MODE: STATIONARY

H.

	ADDS 1 MIL ON ELEVATION QUADRANT. RELEVELS BUBBLE USING MANUAL ELEVATION CONTROL HANDLE WAITS FOR LOADER TO SAY, "UP" USING MANUAL TRAVERSING CONTROLS-TRAVERSES TURRET 50 MILS TO THE RIGHT SAYS, "ON THE WAY" USING MANUAL TRAVERSING CONTROLS-TRAVERSES TURRET 100 MILS TO THE LEFT WAITS FOR LOADER TO SAY, "UP" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CONTROL HANDLE. SAYS, "END OF MISSION" WAITS FOR COMDR TO SAY "CEASE FIRE OR ISSUE OTHER COMMANDS"	PLETELY CLOSED STANDS CLEAR OF BREECH SAYS, "UP" WAITS FOR GUN TO FIRE LOADS 5TH ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS FULLY CLOSED STANDS CLEAR OF BREECH SAYS, "UP" PLACES MAIN GUN SAFETY IN SAFE POSITION WAITS FOR COMDR TO SAY, "CEASE FIRE" OR ISSUE OTHER COMMANDS	
OBSERVES TARGET AREA FOR WEAPON EFFECTS. PREPARES TO ENGAGE TARGETS WITH DIRECT FIRE IF THEY SHOULD BECOME ILLUMINATED **SAYS, "CEASE FIRE" AFTER THE 5TH ROUND IS FIRED.**			DRIVER PREPARES TO START THE TANK ENGINE AS SOON AS THE FIRING PATTERN HAS BEEN COMPLETED AND BE PREPARED TO MOVE TO AN ALTERNATE FIRING POSITION UPON ORDERS FROM THE COMDR

CONDITIONS

CREW MEMBER FIRING: GUNNER

VEHICLE MODE: STATIONARY

VISIBILITY: NIGHT

FIRE CONTROL INSTRUMENT: AZIMUTH INDICATOR
ELEVATION QUADRANT

FIRING MODE: STATIONARY

TARGET: P C's (ARMORED PERSONNEL CARRIERS)

RANGE: 1800 METERS

TABLE 4-9 INTERACTIVE CREW TASKS (MAIN GUN-RANGE CARD ENGAGEMENT)

TANK COMMANDER	GUNNER	LOADER	DRIVER
COMDR RECEIVES A WARNING OF APPROACHING ENEMY. THIS IS USUALLY GIVEN BY: GROUND SURVEILLANCE PERSONNEL SIGNAL DEVICES GROUND SENSOR TEAMS AERIAL FLARES LISTENING POST PERSONNEL THE COMDR COULD ALSO DETECT THE ENEMY APPROACH BY ONE OF THE CREW MEMBERS ON WATCH USING THE NIGHT VISION EQUIPMENT ORGANIC TO THE TANK. RECEIVES TARGET ACQUISITION REPORT	WAITS FOR COMDR TO SAY, "GUNNER"	WAITS FOR COMDR TO SAY, "RANGECARD"	RECEIVES ALERT FROM OTHER CREWMEMBER AND PREPARES FOR TARGET ENGAGEMENT
ALERTS THE CREW OBTAINS FIRING DATA FROM RANGECARD CHECKS TO SEE THAT HEP IS INDEXED. CHECKS TO SEE THAT MOVING/STATIONARY SWITCH ON AMMO SELECT UNIT IS ON STATIONARY SAYS, "GUNNER"			
SAYS "FIVE ROUND PATTERN"	TURNS TURRET POWER SWITCH TO "ON". TURNS MAIN GUN SWITCH TO "ON" CHECKS TO SEE THAT MOVING/STATIONARY SWITCH ON AMMO SELECT UNIT IS ON STATIONARY		
SAYS, "RANGECARD"	WAITS FOR COMDR TO SAY, "HEP"	KNOWS THAT HEP AMMUNITION IS USED FOR FIRING A RANGECARD ENGAGEMENT. DETERMINE IF A ROUND OF HEP HAS BEEN PREVIOUSLY LOADED. IF NOT, PREPARES	

			HEP HAS BEEN PREVIOUSLY LOADED. IF NOT, PREPARES TO LOAD A ROUND OF HEP. CHECKS TO SEE THAT MAIN GUN SAFETY IS IN SAFE POSITION. LOCATES HEP ROUNDS IN READY RACK. UNLOCKS READY RACK.		
12	SAYS, PC'S (ARMORED) PERSONNEL CARRIERS) SAYS "HEP"	WAITS FOR COMDR TO SAY THE DEFLECTION READING	KNOWS THAT HEP AMMUNITION IS USED FOR FIRING A RANGECARD ENGAGEMENT. DETERMINE IF A ROUND OF HEP HAS BEEN PREVIOUSLY LOADED. IF NOT, PREPARES TO LOAD A ROUND OF HEP. CHECKS TO SEE THAT MAIN GUN SAFETY IS IN SAFE POSITION. LOCATES HEP ROUNDS IN READY RACK. UNLOCKS READY RACK		
	SAYS, "DEFLECTION TWO EIGHT HUNDRED"	CHECKS TO SEE THAT HEP HAS BEEN INDEXED TRAVERSES TURRET USING MANUAL CONTROLS UNTIL 2800R IS INDICATED ON THE AZIMUTH INDICATOR. SAYS, "DEFLECTION TWO EIGHT HUNDRED - RIGHT" SLIPS AZIMUTH INDICATOR GUNNER'S AID AND PLACES ZERO INDEX MARK ON 2800R WAITS FOR COMDR TO SAY THE QUADRANT ELEVATION READING	LIFTS AND LOADS 1ST HEP ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS FULLY CLOSED. STANDS CLEAR OF BREECH.		
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ING SAYS, "QUADRANT PLUS TWO FIVE" INDEXES 1800m INTO THE RANGEFINDER SAYS, "RANGE ONE EIGHT HUNDRED" WAITS FOR LOADER TO SAY, "UP"	INDEXES PLUS TWO FIVE ON THE ELEVATION QUADRANT SAYS, "QUADRANT PLUS TWO FIVE" WAITS FOR COMDR TO SAY THE RANGE TO THE TARGET USING MANUAL CONTROLS-ELEVATES OR DEPRESSES MAIN GUN UNTIL BUBBLE IN QUADRANT IS CENTERED CHECKS TO SEE THAT 1800m HAS BEEN INDEXED INTO THE COMPUTER	OBSERVES TO SEE THAT ROUND IS FULLY CLOSED STANDS CLEAR OF BREECH		
SAYS, "FIRE" WAITS FOR GUNNER TO SAY, "ON THE WAY"	KNOWS THAT THERE ARE TWO FIRING PATTERNS, ONE FOR TARGETS OVER 2000m AND ONE FOR TRAGETS 2000m OR LESS. FIRES CORRECT PATTERN. WAITS FOR LOADER TO SAY, "UP" SAYS, "ON THE WAY" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CONTROL HANDLE ADDS ONE MIL ON THE ELEVATION QUADRANT. RELEVELS BUBBLE USING MANUAL ELEVATION CONTROL HANDLE SAYS, "ON THE WAY" WAITS FOR LOADER TO SAY "UP" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CONTROL HANDLE DROPS 2 MILS ON THE ELEVATION QUADRANT ELEVATION CONTROL HANDLE WAITS FOR LOADER TO SAY "UP" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CON-	PLACES MAIN GUN SAFETY IN FIRE POSITION SAYS, "UP" WAITS FOR GUNNER TO SAY, "ON THE WAY" TURNS VENTILATING BLOWER SIWTCH TO ON POSITION LOADS 2ND ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS FULLY CLOSED. STANDS CLEAR OF BREECH. SAYS, "UP" WAITS FOR GUN TO FIRE LOADS 3RD ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS COMPLETELY CLOSED STANDS CLEAR OF BREECH SAYS, "UP" WAITS FOR GUN TO FIRE LOADS 4TH ROUND	DRIVER KEEPS HIS EYES CLOSED BETWEEN THE FIRING OF EACH ROUND IN ORDER TO RETAIN HIS NIGHT VISION	

3

.4

	TROL HANDLE. SAYS, "ON THE WAY" ADDS 1 MIL ON ELEVATION QUADRANT. RELEVELS BUBBLE USING MANUAL ELEVATION CONTROL HANDLE WAITS FOR LOADER TO SAY, "UP" USING MANUAL TRAVERSING CONTROLS-TRAVERSES TURRET 50 MILS TO THE RIGHT SAYS, "ON THE WAY" USING MANUAL TRAVERSING CONTROLS-TRAVERSES TURRET 100 MILS TO THE LEFT WAITS FOR LOADER TO SAY, "UP" SQUEEZES FIRING TRIGGER ON MANUAL ELEVATION CONTROL HANDLE. SAYS, "END OF MISSION" WAITS FOR COMDR TO SAY "CEASE FIRE OR ISSUE OTHER COMMANDS"	OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS COMPLETELY CLOSED STANDS CLEAR OF BREECH SAYS, "UP" WAITS FOR GUN TO FIRE LOADS 5TH ROUND OBSERVES TO SEE THAT ROUND IS FULLY CHAMBERED AND BREECH IS FULLY CLOSED STANDS CLEAR OF BREECH SAYS, "UP" PLACES MAIN GUN SAFETY IN SAFE POSITION WAITS FOR COMDR TO SAY, "CEASE FIRE" OR ISSUE OTHER COMMANDS	
OBSERVES TARGET AREA FOR WEAPON EFFECTS. PREPARES TO ENGAGE TARGETS WITH DIRECT FIRE IF THEY SHOULD BECOME ILLUMINATED SAYS, "CEASE FIRE" AFTER THE 5TH ROUND IS FIRED.			DRIVER PREPARES TO START THE TANK ENGINE AS SOON AS THE FIRING PATTERN HAS BEEN COMPLETED AND BE PREPARED TO MOVE TO AN ALTERNATE FIRING POSITION UPON ORDERS FROM THE COMDR

CONDITIONS

CREW MEMBER FIRING: GUNNER

VEHICLE MODE: STATIONARY

VISIBILITY: NIGHT

FIRE CONTROL INSTRUMENT: AZIMUTH INDICATOR
ELEVATION QUADRANT

FIRING MODE: STATIONARY

TARGET: P C's (ARMORED PERSONNEL CARRIERS)

RANGE: 1800 METERS

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Except in range card firing, the crew's goal is to obtain a first-round hit in as short a time as possible, and, if the first round misses, to obtain a hit by adjusting fire. The crew also attempts to fire the first round as rapidly as possible, not only to obtain a first-round hit, but, if possible to spoil the aim of the threat.

A great deal of armor crew training is intended to standardize individual and crew performance so that essential procedures can be performed with little or no conscious thought. Since no two combat engagements are expected to be alike, there is also emphasis on training crews to recognize essential differences in missions and engagements so that procedures can be selected to meet those differences which are critical for mission success. Although each member of the crew responds to the direction of the tank commander, each is responsible for taking the initiative, as required to enhance the effectiveness and/or the security of the tank and its supporting elements. The driver is in the most critical position to sense and respond to critical variations in the tactical situation, since it is he who has the most immediate control over movement and position, and thus the exposure and vulnerability of the tank. Ordinarily, the driver expects to receive a command telling him when and where to drive for the gunner or the tank commander to fire. He expects to remain stationary until the fire mission is complete. The skilled driver tends to stop before the command is given, and to select a position which optimizes security and target acquisition. He also tends to move out when he sees that the target has been destroyed, or when he detects another threat preparing to engage his tank.

The gunner and the loader can also help to maximize tank effectiveness by taking the initiative, but primarily they alert the crew to threats or possible threats. They can also provide valuable guidance to the driver in the selection and negotiation of his route to the objective, but their workload and their limited visual contact with the terrain make this difficult. The gunner's periscope is sometimes used in evaluating terrain surfaces and obstacles at a distance. Even the coax can be used by the tank commander or the gunner to evaluate terrain surface characteristics for the driver. The impact of 7.62mm ammunition can sometimes indicate whether the surface is soft or hard as rounds will ricochet or throw up dust from hard surfaces, and show little or no impact at all in soft surfaces.

Each member of the crew learns something of the job of each other member so that coordination can be accurate and timely. Each crew member also, learns to do the job of other crewmembers so that each can substitute for the other if necessary. In combat, it is not unusual for a tank to operate with three crewmembers instead of four. Tank commanders riding in the open hatch are especially vulnerable. If the tank commander is hit, he is usually replaced by the gunner, since the gunner is usually the most experienced of the three other crewmembers. Also,

the gunner can operate from the tank commander's position in much the same way he would operate at his own station. Operating with a three-man crew degrades tank performance by making it necessary for the main gun to be fired from the tank commander's position. When the rangefinder is out of order and the main gun is fired at targets beyond battlesight range, the gunner should use the telescope but it can be used only from the gunner's station. If the gun is fired from the telescope, the crew loses the advantage of surveillance from the tank commander's cupola. Specific circumstances dictate the most effective course of action, and may result in the loader firing from the gunner's position which, of course, means that he must move out of the seat to reload for sustained fire. This can be effective when the tank must move between rounds, and when the target, such as a fortification, cannot return effective antitank fire between rounds.

4.6 Utilization of Tactical Information

The M60A3 crew needs as much information as is available concerning the situation in which they are involved at any given time. Specifically, they need to know the enemy, terrain, weather, and support available to them in their mission. Tactical information is obtained by direct (and IR) viewing of the battlefield, communications with scout elements and advanced combat elements, aerial photographs, premission briefings, and observation of threat activities prior to and during the mission.

The mission is usually defined in terms of the objective, routes available to the objective, and the objective's defenses. The mission description also defines the manner in which the tank is to maneuver with other tanks and friendly elements, maintaining security and mobility while applying fire to the objective and to hostile elements encountered enroute. Ordinarily, tank attacks involve at least platoon-size units, generally in two-tank elements. One tank in an element moves from one position to another while the other tank supplies covering fire. Defensive missions require similar cooperation, but movement is limited to that required to optimize firing and defensive positions as the threat approaches.

Information about the enemy is vital to the success of the tank mission because it defines weapons, ammunition, and tactics required, and it helps to define the ways in which enemy forces may be deployed and moved. If a tank encounter is anticipated, the crew knows that the terrain over which they could move must be carefully searched. When aircraft are expected to be encountered, the tank commander knows that he must divide his attention to engage with his .50 caliber weapon and that he must constantly search for different kinds of cover than is needed for security from ground forces.

Terrain and the weather conditions have profound effects on M60A3 crew operation, by determining routes which can and cannot be taken, the speed with which the tank can move and its maneuverability and agility. These factors also influence the crew's range of visibility and determine its vulnerability to ambush and surprise. Terrain and weather also effect the tank by defining the positions and routes various threat elements can employ. Careful study of the terrain can tell the crew where threats could be hiding, and where their weapons could be sighted so that these areas can be avoided, and searched more carefully for subtle signs of threat activity. Rain, snow, and ice can effect both the M60A3 and the threat, further channeling and slowing movement.

Snow, rain and fog can be used to advantage, in making movements more secure than they might otherwise have been, although they do require special route negotiation and battlefield surveillance skills on the part of the crew.

Support information is extremely important to the tank crew. The tank, by definition, almost always operates in support of some other element, whether it is another tank or infantry elements. Ordinarily, the tank itself ~~is~~ also supported by other elements, either directly or indirectly. The types and amount of support available strongly influence the way in which the tank performs its mission. Artillery can neutralize threats which are inaccessible or invulnerable to the tank's weapons. Artillery can also prevent dismounted troops from attacking the tank with ATGM's and other anti-tank weapons, although antipersonnel artillery fire can also force the tank to be operated with hatches closed or propped. Air support can greatly reduce the effectiveness of armored threats to the M60A3 by engaging tanks and other heavy weapons. By the same token, anti-aircraft artillery can reduce the effects of enemy air-to-ground antitank systems.

The most elementary type of support available to the tank is other tanks in the same or adjacent units. Mutual support among tanks in a maneuver element or in a platoon involves radio and standard operating procedure (SOP), in addition to extensive visual contact with the other elements and with the effects of their weapons.

Tactical information is used in the identification of possible threat areas capable of supporting the movement of various kinds of threats. It is used to identify safe, fast routes for movement, to determine the amount and type of ammunition to be carried and its arrangement in the ready-rack. Tactical information is also used to estimate the speed of movement, maneuvers most likely to be effective, and the types of intelligence and fire support to be expected during a mission. Tanks operating

without support are extremely vulnerable, and must move cautiously, making extensive use of cover and concealment. Tanks operating with mechanized infantry can move more quickly with less concern for close-in threats. Tanks with air support can concentrate on targets requiring sustained fire, leaving many lightly armored and point targets for the armored helicopter in strike aircraft. Air support also means more accurate, and longer range target acquisitions which greatly enhance the ability of the tank to accomplish its mission, and to maintain its own security.